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Cover: *A* tovil *performer from Sri Lanka assumes the appearance and role of a demon, which he will exorcise after dancing into trance. Photograph by Yvonne Hannemann. Story on page 42.*



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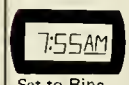
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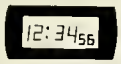
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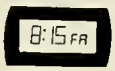
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Michael M. Ames, professor of anthropology and director of the Anthropology Museum at the University of British Columbia, was instrumental in giving visitors unlimited access to everything the museum owns, thanks to a system, initiated in 1976, that he describes as "visible storage." Although he did his first research among Northwest Coast Indians, Ames became interested in Sri Lanka while pursuing Southeast Asian Studies in graduate school. He has made three field trips to the island to study religion and social change.



For the past ten years **Len Aronson** has worked for the Society for the Protection of Nature in Israel. The behavior and ecology of the Nubian ibex has been the focus of his recent fieldwork, which ties in with the Israeli government's desire to preserve this species. As senior instructor at the Ein-Gedi Field Station, located on the shores of the Dead Sea, Aronson is also deeply involved in educational programs to increase the public's awareness of its natural surroundings.



An associate curator in the Department of Herpetology, **Charles J. Cole** began his career at the American Museum of Natural History after receiving his Ph. D. from the University of Arizona. His study of parthenogenesis in lizards was an outgrowth of his investigation into evolutionary relationships of reptiles and amphibians and how species are formed. Cole's herpetological perambulations have taken him to many a lonely stretch in the Southwest and in Mexico. Asked about his future research plans, he responded, "More of the same."



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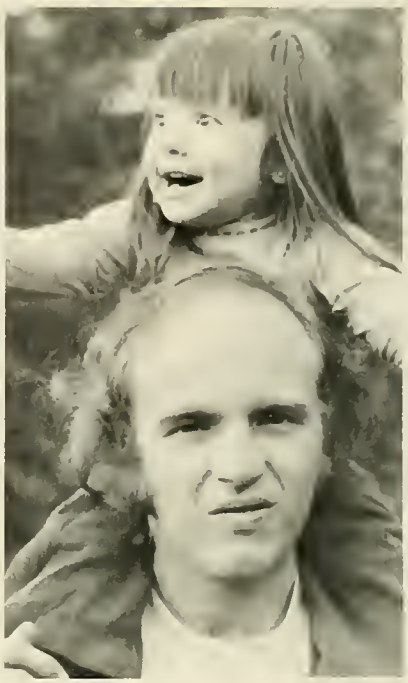
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A native Texan who has just moved to Canada, **William Cade,** shown here with his daughter Tamez, is assistant professor of biological science at Brock University in Saint Catharines, Ontario. In 1972, while doing graduate work at the University of Texas at Austin, Cade became curious about crickets and other insects that communicate with each other acoustically. "I began graduate school during a period of virtual revolution in evolutionary theory," he says, "and my scientific interests changed from cell biology to ecology and the evolution of animal behavior." He subsequently wrote his doctoral thesis on the sexual behavior of the field cricket, readily observed in Texas. Since crickets and their relatives are agricultural pests in the United States and other parts of the world, Cade hopes that his basic research may also prove utilitarian.

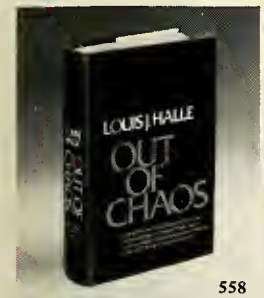
In the belief that anthropology students become better anthropologists if they understand their own culture, **Conrad P. Kottak,** who teaches at the University of Michigan in Ann Arbor, has spent considerable time at a nearby McDonald's restaurant. The data he has gathered there contribute to the material he uses in his undergraduate anthropology courses. Kottak plans to examine the significance of such manifestations as Walt Disney's creations, the movie *Star Wars*, and the effects of advertising and politics on American pop culture. In pursuit of more information on these subjects, he frequently watches television, reads magazines, and accompanies his children to different fast-food restaurants.





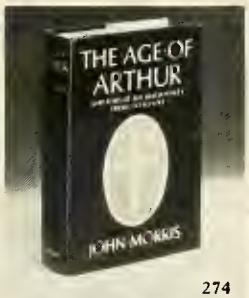
A naturalized United States citizen, **Richard Goody** has been at Harvard University ever since he came to this country from his native England twenty years ago. He has been interested in planetary astronomy for an even longer period. Currently a professor of planetary physics, Goody got his B.A., M.A., and Ph.D. degrees from Cambridge University. His present research centers on the meteorology of Venus, Martian dust storms, and the plasmasphere of Jupiter. His future projects include studying the satellites of the outer planets. Goody is a Fellow of the American Academy of Arts and Sciences, a member of the National Academy of Sciences, and the author of several books.

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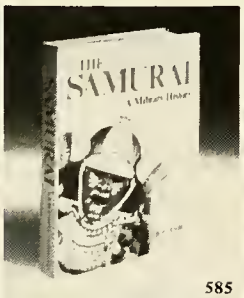
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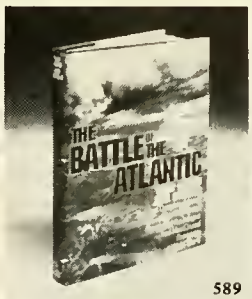
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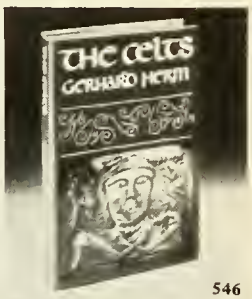
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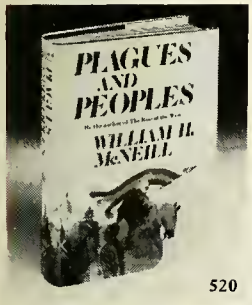
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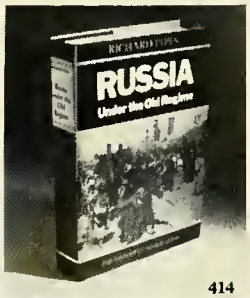
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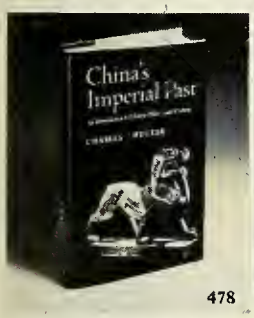
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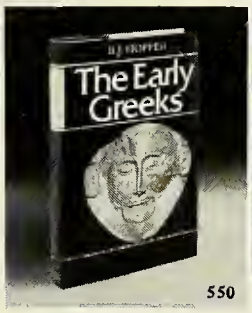
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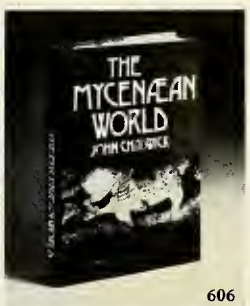
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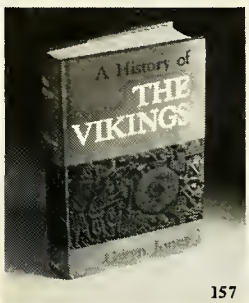
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As I grow older, I incline more readily to the view that the whims of the aged should be treated with at least grudging respect. For instance, I side with the senescent but normally sophisticated New York publisher whose quirk it was to take iced coffee with lunch—every lunch. After a long career, the publisher moved his office to a building directly across the street from an expensive French restaurant whose proprietor, a martinet in almost every respect, surpassed even his usual hauteur on the day he refused to serve the elderly bookman coffee with his *timbale de homard.* That this misplaced gastronomic strictness cost the restaurateur thousands of dollars in expense account editorial lunches (and that similar acts of rudeness soon alienated many more clients and forced the restaurant to close) is a just and fitting reminder that fine dining should not be encumbered with rigid rules. On the other hand, it is fair to say that the literary graybeard had violated good taste, but he did so in a thoroughly American way.

Few commentators on our domestic habits—even Tocqueville neglected this point--have remarked that, unlike the people of other cultures. Americans swill coffee with their meals. This is an abomination almost as noxious as the Scandinavian predilection for combining food with glasses of hard liquor, for coffee is one of the very few things we can consume that has a truly bitter taste. By itself, a carefully brewed, aromatic cup of coffee is a wonderful thing. It does not, however, go with either meat or fish. Coffee does complement sweet foods, and I think that the insistence of some European restaurants that coffee must always be a separate course served with ceremony after dessert is needlessly fastidious. Yet this severity points in the right direction. Good coffee is a rare and hard-won treat, difficult to prepare and worth attending to without the distraction of other tastes and smells. Really good coffee can be as overwhelming to the senses as a fresh truffle. I recall tasting a cup, absentmindedly, after a splendid dinner in a Brazilian expatriate's house and snapping to surprised attention. I complimented my host, who explained, somewhat embarrassed at my slowness, that he was an importer; coffee was his business.

You don't have to be a Brazilian coffee broker to have good coffee at home, but it helps. Coffee is not a simple drink. It is much more difficult to be sure of finding good coffee than it is to know that you

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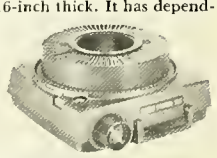
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have laid your hands on a respectable bottle of wine, because coffee is not labeled or controlled with anything like the precision of wine. Still, with the recent rise in coffee prices, a good cup of Mocha-Java may soon cost as much as a glass of Chambertin.

Whatever other thoughts the current coffee shortage may provoke, when we pay more than $4 a pound for supermarket, canned, run-of-the-mill stuff, it is time to take a serious look at this curiously stimulating decoction of the fruit of *Coffea arabica,* which we have been downing with such nonchalance for so long.

A good cup of coffee is the end of a complex chain of transmission that begins in such exotic tropical highlands as the Blue Mountains of Jamaica, the Colombian cordillera, or the Harar district of Ethiopia, where coffee shrubs first grew in the wild. Coffee's cherrylike fruit was eaten for protein and fermented for wine before its inner bean was boiled to make the beverage we love. By about 1600 it was well known in western Europe. Coffeehouses started up everywhere and became centers of urban social life. Louis XIV backed an ultimately successful French horticultural effort that culminated in coffee plantations in Martinique (and subsequently, all over the tropics of the New World). Coffee (whose English name is a cognate of an Arabic word that probably came into the language via a Turkish variant) is now a worldwide or, at least, a third-world-wide crop. Green beans (what is left after the fleshy outside of the berry is removed) come to us from around the globe. And it is the devil's own job for the layman to choose among them.

One certainty is that canned commercial coffee is the lowest echelon in the retail coffee marketplace. Brand-name coffees are blends, and they increasingly contain admixtures of an inferior, insipid strain of coffee, *C. robusta.* Stepping up the ladder to whole roasted beans, we enter a chaotic but fascinating arena of warring claims. Quality beans—even if correctly labeled—come in many grades, from many places within the general growing area identified by a label. Just as hillsides in Burgundy differ, so do hillsides in coffee-growing regions of Costa Rica. At today's prices, one wants to be sure of what one is purchasing, but the fact is that the specialty coffee merchants have us by the short hairs. We can never be sure that the Medellín beans in the picturesque sack—side-by-side with many equally picturesque sacks—are as good as we would like. Some aficionados will taste whole beans or scrutinize them to see that they are not mottled, suitably uniform, and lustrous with oil.

Roasting, especially the protracted dark roasting favored by Italians and others in the know, brings oil to the surface of the bean. In my neighborhood, there used to be a wise old Italian coffee man whose store was dusty and aromatic; he roasted his own beans every day on the premises. This was a rare opportunity and it ended when he closed up shop a few years ago. Now I see how important it is to get fresh-roasted beans. After a few days the oil begins to go rancid. To combat this, connoisseurs refrigerate whole beans in airtight glass containers. They buy in small quantities, enough for a week or two, and grind what they need as they need it. Whole beans retain their flavor much longer than ground coffee. But, then, purists fight over which is the best kind of grinder and how fine to grind. Educated opinion seems to align itself with burr-type electric grinders adjusted to produce the finest grind short of powder (real pulverization vaporizes the oil and defeats the purpose of the exercise). All these gyrations lead ultimately to the parlous act of brewing. Here, a few basic principles determine everything, and they are all meant to produce a pure, strong coffee aroma.

For the perfect cup of coffee, you must combine the best water available, at a temperature just below boiling, with the best beans you can get. This must, logically, occur in some sort of vessel. Glass and ceramic finishes are ideal. Metal of almost any sort picks up an off-taste and/or adds its own to the coffee.

Some people simply put coffee in an enamel saucepan, pour very hot water over it, wait until flavor develops, and get the floating grounds to settle to the bottom by adding eggshell or a small amount of cold water. Such "prospector's coffee" is as good as can be, but it is a mess. Indeed, figuring out what to do with the grounds is the main mechanical



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problem of coffee making. It has led to scores of solutions too familiar to mention. The filter-drip method is the experts' favorite. You just fold up the filter paper around the grounds and throw them out. The urn is glass or pottery. And there you are. Except for one thing. Coffee gets cold and does not reheat well. A thermos is the best solution. It preserves the flavor, although aroma is irrevocably lost after those first few minutes. Cold coffee can be used for iced coffee or even drunk at room temperature. Any Italian café will serve you *caffé freddo* on request and without treating you like a lunatic. In Bologna, even cold coffee can taste good.

Coffee also has a limited range of uses in cooking. Primarily, it shows up as a flavoring element in pastry cream, in ice cream, and in mousses. Since the cook in these cases wants intense flavor, but as little liquid as possible, freeze-dried coffee is a good source. It dissolves easily in a bit of cold liquid. Aroma is not an issue in a coffee eclair; so the usual deficiencies of freeze-dried coffee don't matter. And the flavor of freeze-dried crystals is generally superior to that of instant powder.

Coffee is, of course, not only a flavorful drink, it is also a drug or rather it contains one, caffeine. Caffeine may be harmful to some people's health, and it may keep some people up or make them jittery. Such people can always abstain or choose flat, decaffeinated coffee. Or they can opt for abstemious self-indulgence: they can decide to drink small amounts of very good coffee. Putting the standard two tablespoons of ground coffee into six ounces of water per cup twice a day, they will risk little and improve the enjoyment of life through astute exploitation of a useful plant. It is also the case that one pound of coffee yields more than fifty such cups. And should coffee climb to $10 a pound, think of it as twenty cents per marvelous cup.

So drink less and enjoy it more. T.S. Eliot had it all wrong. His character Prufrock should have rejoiced, not whimpered, when he said: "I have measured out my life with coffee spoons."

Raymond Sokolov is a free-lance writer whose special field of interest is the history and preparation of food.

ERRATA: We regret mixing our fruits and inadvertently substituting a photograph of a fig tree for a date palm in October's column. Also, the figures for dates produced in California and imported dates should have read "thousands of tons," not millions.

Frozen Coffee Mousse

4 egg yolks
¾ cup superfine sugar
2 tablespoons freeze-dried coffee
4 egg whites
1 tablespoon sugar

1. Beat the egg yolks, superfine sugar, and coffee together until thoroughly mixed. If the coffee granules do not completely dissolve into the mixture, proceed anyway to the next step.
2. Heat the mixture from step 1 in a heavy-bottomed saucepan over low heat. Beat constantly for 3 or 4 minutes with a whisk. When the mixture thickens, set the saucepan in a shallow pan containing cold water and continue beating. This will give you a chance to mix in any remaining coffee granules and will also prevent the mixture from overcooking. Be alert during the cooking stage; as soon as the mixture begins to stick to the pan or to curdle, remove to the pan of cold water.
3. Beat the egg whites until they form soft peaks. Add the sugar and beat some more, until stiff peaks form.
4. Stir a quarter of the egg whites into the yolk–coffee mixture to lighten it. Then fold in the rest of the egg whites.
5. Transfer the mousse to a serving dish. Place in the freezer. After an hour or so, fold the mousse into itself; some separation will probably have taken place. Be careful to preserve as much air and lightness as possible. Test the mixture again after another hour and fold again if necessary. Continue in this manner until folding is no longer necessary. Before sitting down to dinner, remove from the freezer to soften the mousse slightly.

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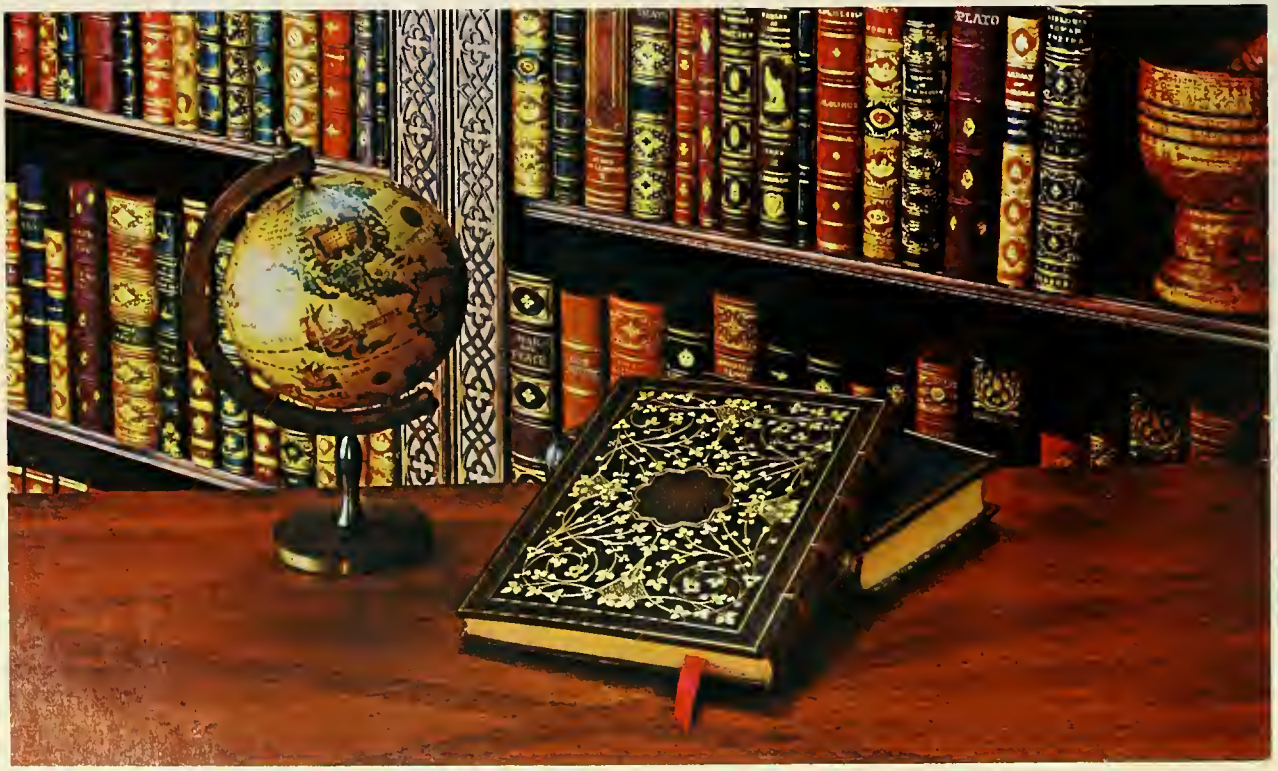
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The Great Energy Standoff

by Luther P. Gerlach

Shortages, Arabs, and technology may hurt energy plans, but they can't compare with a few determined Minnesota farmers

On a small hill near Scott Jenks's dairy farm outside the town of Lowry in west-central Minnesota, a large hand-lettered poster proclaims: "God made this land for growing food, not for power lines."

For five frigid November days more than a year ago, farmers and their townsfolk neighbors gathered on that hill to block surveying for construction of a high-voltage transmission line. A few weeks later I sat with some of the participants in the community room of the Lowry Lutheran Church, as they explained what had happened on the hill.

"We blocked them with our bodies and our equipment," explained Scott Jenks, 59. "We stood in front of the surveyors' transits and their aiming stakes. And we ran chain saws so that they could not talk to each other by walkie-talkie. But there was no violence. We wouldn't have any of that."

"When the sheriff told one of us to move on, we did," observed Gurvin Femrite, 39, who came up to help Scott soon after trouble started. "But then someone else just stepped in to take our spot."

"When I saw Scott and our neighbor Tony Bartos parking the silage wagon in front of the surveyors, I got worried," added Mrs. Jenks. "We knew what had happened over in Meeker and Stearns counties, you see. So I got on the phone and started calling the others in our group. And then they called others."

Art Isackson nodded. "And we came. I guess at one point we had 200 out there. Not just farmers, but also people from the towns—businessmen and others. And they came from all over. From some of the other groups in the other counties where the line will go. If this would have gone on another day or if we have to do it again, we would get maybe 500 out."

"Reporters and city people just don't seem to understand this," explained Carolyn Koudela, 41, a farm wife and president of one of the resister groups, Save Our Countryside, or SOC. "We are very individualistic. Our land is our land. Each of us will farm it in his own way, and no one can tell him he must change. But when one of us is in trouble, everyone will rush to help. Like when the tornado struck two or three years ago and hit a barn north of Lowry. Within two hours the neighbors had the livestock rounded up and all the wreckage cleared. So when our land is threatened by the power line, we all help. It's our way."

"I don't know how we would have fed 500," sighed Esther Hedlin, 60. "We had trouble as it was—but we managed. First we made coffee, and it went on from there. The more that was needed, the more we provided."

"One report in the paper said that you also fed the surveyors," I observed.

"Of course," smiled Mrs. Jenks, "we really have nothing against them as persons. It's what they represent." (The surveyors were employed by two collaborating rural electric cooperatives.)

"Someone did let the air out of Kingsley's car tires—he's the co-ops' field representative—but Scott had his son pump them right back up.

"I guess it was Kingsley who said on TV that we should all be in the slammer for what we were doing."

When I asked if that was why they called the place where they resisted the surveyors Slammer Hill, they nodded affirmatively. "That's what we called it at first. It was a risk we were willing to take, being arrested. There is just no way we are going to let the line cross our land. But since it's our rights and our land we are fighting to protect, we gave the hill a new name."

"What's that?"

"Constitution Hill. The name's still up there on the canvas we stretched across the top of the township road. You have to see it."

Later I did visit the "Hill"; I spoke to farmers and businessmen, and heard them express over and over why they believe the transmission line is a threat to rural life, to their health and welfare, to their ability to farm effectively and produce food to feed the world, and to their sense of integrity and justice.

Scott Jenks and his wife explained how they built up the farm they had bought in 1952 with the last of their savings. "We sold everything we had and moved up here with nothing but our car and some furniture. We had real rough sledding at first. Food prices were way down at the time. We were feeding hogs, but got nothing for them. But we made it. I can remember wearing the same shoes, patching the soles, year after year. But we raised six fine children and built a real fine operation.

"The two girls are nurses, and two of the boys are farming rental land. When they finished school, we sold the dairy herd; now we concentrate on small grains—wheat, soybeans, oats. And I also have a backhoe and do some earth moving on contract. We did a lot of work ourselves on our new house. We've thought about selling rather than live under the line. But when prospective buyers hear that this is where the big line is going to come, they lose interest."

"I've heard that the governor and some legislators are talking about the state and the co-ops buying out a person who just cannot bear to live with the line," I commented. "Would this satisfy you, particularly if they paid what you asked?"

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"No, it's like being forced off your land. Maybe at one time if they would have offered us enough, we would have taken it. But now we are not going to give in."

"It's a principle we're fighting for—and a way of life," Carolyn Koudela explained. "Family farming is a good way of life. We are not all millionaire farmers. Many owe a lot for their land, for equipment, parts, and fertilizer. But they all take pride in what they do. And not just the elders. My husband's people have been farming here for three generations, and I am sure that there will be a fourth generation for the simple reason that we have two sons, we have four daughters. Some will be working elsewhere, but some will farm. They just love the land, this way of life. There's a freedom in it."

"We have 520 tillable acres of good soil, black and heavy," Gurvin Femrite declared, as we drove around his fields. "We raise wheat, barley, corn, and beans and feed up some beef cattle. Even though they called it a drought last year, we grew enough beans to win a five-state contest. We planted double rows. The prize was a trip to Las Vegas. We would never have gone otherwise; it's just too expensive. The power line is supposed to go right where we grew the beans. They take a 160-foot-wide easement and put the line in the center of it."

We stopped on a corner of his land and looked around. Heavy winds had drifted the shallow snow. The land was broad and flat: Lowry, the highway, and Jenks's hill rose several miles to the east. It looked beautiful, even under the cold gray sky. As we drove on, Femrite interrupted my musing: "That's the Hedlin's place over there, Esther and her brother."

"Was it Esther who said they are worried that the line goes over their drainage ditch and they won't be able to get a dragline in to keep it open?"

"Sure, it's something to worry about. You need good drainage here. And it's the same if it goes over the Lowry sewage lagoon; they won't be able to dredge it."

We turned into Femrite's place and he pointed out the metal barn he had just erected to store machines and green crops. "According to the new route, the line would be about 500 feet from it. And then it would probably go over where Myra has her vegetable garden. So we wonder, can we really keep on living here? Is it fair to our children? They are the fourth generation of Femrites. But with the line, they will get the land in worse shape than when we got it. Mostly, we worry what may happen to them if they grow up under the line."

Joining our wives for coffee in the Femrite's comfortable kitchen, we talked about the resisters' concern that since "the line" is larger than anything else in the upper Midwest—two direct current lines, each able to carry 400 kilovolts—they consider it a major, untested risk to health and safety. We discussed how other power line resisters (especially Jim Nelson, 32, in Grant County—a farmer with a master's degree in physics), have put together reports that warn of the way such lines could emit ozone or produce electromagnetic fields and induced currents.

"The cooperatives tell us there is no risk, but when we read the reports of the Russian experiments and the testimony of those New York doctors. . . ."

"Marino and Becker? But their research was on 765-kilovolt lines, alternating current."

"Still, it makes you think. As Verlyn Marth says, 400 kilovolts in each line means 800 kilovolts. The point is, we just don't know. Now the state is going to have the university monitor the line for the effects of ozone."

"So we are the guinea pigs." Myra shook her head, poured more coffee. "We and our three sons. Are we just supposed to wait and hope the co-ops are right? Is it fair to our children?"

Together with her neighbor Nina Rutledge, Myra leads a Cub Scout den. They talk about how they stood together on Constitution Hill all morning resisting the surveyors, singing "God Bless America" and "We Shall Overcome" to drown out the sheriff's attempts to read an order to disperse. Then they broke off, went home, picked up the Cub Scouts, and drove them to the TV station in Alexandria, some thirty miles away, so that the Cubs could see how a TV show was produced. At the station, one of the reporters stared at them, did a double take, and asked if he had not seen them before—on the Hill that morning.

"He seemed surprised," noted Nina. "We were in a different context. Maybe at first he couldn't believe that the same people who were on the Hill would also be den mothers."

Nina and her husband, Dennis, are newcomers to the area. Dennis, an Annapolis graduate, was a Navy pilot, and still flies in the Reserve. But he grew up on a farm in Benson, Minnesota, and always wanted to get back to farming. Despite the risk in leaving the security of the service, he and Nina took the plunge in 1974 when they found the place they wanted, 210 acres on the highway outside Lowry. They were hit by drought, low prices for their corn and soybeans—and now the threat that the line would cross three-quarters of a mile of their land. "But we'll make it. We're determined."

Rutledges, Jenks, Koudelas, Femrites—newcomers or centennial farmers—they are all determined to maintain their way of life against threats from the outside, to challenge and resist the power line. They are but a tiny sample of the resisters. Some 3,000 people have signed up as members of one or more of at least eleven resister groups—No Power Lines, in one part of Grant County; Save Our Countryside, in Pope; Keep Towers Out, in Stearns—to name but a few. Hundreds came out to block the surveyors at Lowry. Scores came out to block the surveyors in Stearns and Meeker counties.

Since spring of 1974, when the electrical cooperatives first sought easements for the line, hundreds have taken time out from planting and harvesting or braved the snows of winter to challenge the line and face the cooperatives in dozens of local meetings and regional and state hearings. They have contributed uncounted hours and many thousands of dollars to fight the line not only in the hearings but also before the courts and legislature. Some of them have traveled to other parts of the country to learn about power-line fights or related energy matters.

It has cost them in stress and anxiety: "Well, it's really been something I never thought to experience. It's all you think about day or night. I dreamed last night that the thing was finally settled.

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I just can't believe this is happening to us. It's like a horrible dream. We have no control over what happens; they just get their own way with the line."

Yet many also say that through all of this, people and communities have been empowered, enriched; they have never been as together or as alert as they are now. They tell how this struggle has changed them, has opened their eyes to the need to be involved and not just to trust that things will work out.

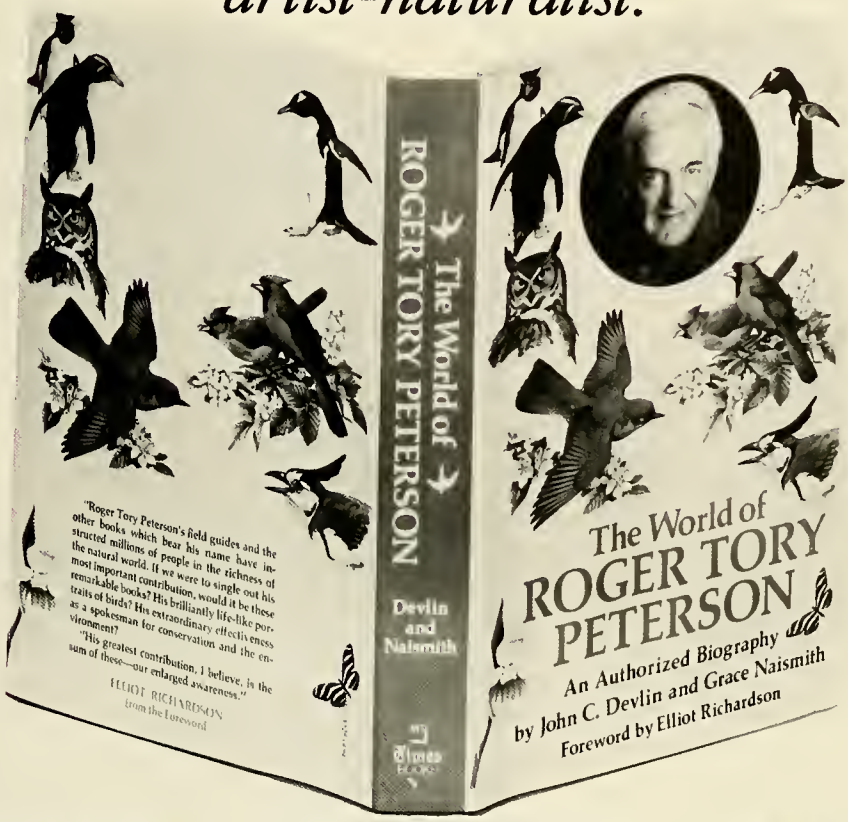
Theirs was the first power line to be routed according to the 1973 Minnesota power plant and powerline siting legislation. This law authorized the Environmental Quality Council (EQC, a board comprised of the heads of seven state agencies, a governor's representative, and four citizen advisors) to determine routes based not only upon recommendations from utilities but also from citizens. As good as this first seemed, the resisters quickly found flaws in it.

"The confrontations have been important," according to Harold Hagen, who has been challenging the line since January 1975. "But now we need to change the legislative procedures, which forced routing the lines over productive cropland."

Hagen, 50, began farming in 1946 at Starbuck, with 160 acres he has since built up into a 1,200-acre enterprise. He grows grain and corn and keeps up to 12,000 chicken and turkey breeders. He spends as much as $400 a month on electricity to ventilate and light the breeders. I heard him speak effectively at hearings, meetings, and press interviews. Now, he and I stood in the middle of the rolling, black-hued acres he had been harrowing and fertilizing with nitrogen sprayed from an ammonia tank hitched to his tractor.

Hagen, who served on the citizen advisory task force to help site the line, described his frustrations: "We were told that the line could not go over state parks and wildlife areas or down highway or railroad rights-of-way. That forced the line onto farmland. Some say it's because the Department of Natural Resources (DNR), the Department of Transportation, and the environmentalists protected their turf. Some say it's because it's easier to build the line over flat farmland."

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"Where is the line going to cross your land?" I asked.

"It's not, not now. It was on the cooperatives' preferred route, but this route was shifted during the hearings."

"Yet you have been working just as hard since then to resist the new route."

"Yes, it's something that had to be done."

I asked if it wasn't also true that some people were helping resist the line even though they never were affected by it.

"Yes, quite a few, like the Koudelas and Cloweses. If we don't work together now, we might be the ones in the future."

"It's not only morally wrong if each person only looks out for himself and tries to shift the line onto someone else's land; it's also tactically wrong," Jim Nelson explained to me in September 1974. "The power company will pick us off one by one." As a township clerk, Jim was one of the first in Grant County to learn that the co-ops wanted to build the line. In 1972 Nelson and his wife had joined his parents in farming 800 fertile acres near Elbow Lake.

Nelson had previously worked in the aerospace industry near Boston. Now, just when the Nelsons were back to rural life, industry was going to march a giant power line right over them and their new house. As he saw it, the small rural co-ops, which had brought electricity to the farms, had become giant companies little different from big utilities. He worried that once the line was in, other utilities would get permission to parallel it with other lines in a wide corridor. So he helped get a group going in his part of Grant County. No Power Lines—NPL—they called it. But he and his fellows also went out to urge others, in neighboring townships and counties, to form their own local groups to resist the line. Meanwhile, others were doing the same, elsewhere.

"The co-ops always look for some type of conspiracy to explain the way they have been confronted," Hagen once observed, "but it's not that way. It has been spontaneous. Our organization sort of builds around the action."

As resisters met, saw a common purpose, and stood together against what seemed to be the overwhelming force of the power co-ops, they found ways to collaborate across the counties. They formed loose coalitions, appointing representatives from each local group to serve on a coordinating board. CURE, Counties United for Rural Environment, emerged.

Resisters also expanded their antiline network by telephoning and writing. The 240-acre Tripp dairy farm near El Rosa has become one of the nodes of this communication system. When the Tripps hear of someone in the state or across the country who has information the resisters need, a service they can use, or has shared common experiences, they will write or call.

Not unnaturally, officials in the energy industry and in government have asked the resisters in Minnesota and elsewhere what they propose to do about getting electricity if the lines are not built. Employees of the embattled Minnesota co-ops, themselves becoming militant, have worn red badges lettered in black, "If the lights go out, call CURE."

There are alternatives, resisters respond. If you won't build the lines along highways or through parks, then build smaller power plants where the power will be used, use solar or wind energy, or put the lines underground. The co-ops explain that these are simply not currently feasible alternatives. But the resisters counter by charging that the power companies are locked into obsolete technology.

Showing us around his place in El Rosa, Virgil Fuchs observed that "if I used the same technology I did even five years ago, I would be finished." He scoops into a bin of golden corn kernels to show how he preserves their food value by spraying them with a new chemical instead of using a propane drier. He wants to irrigate his new fields by a large center pivot system and to spray pesticides, herbicides, and even some seeds from the air. He fears the lines and towers on his land would prevent this. His wife, Jane, stepping down from one of their big tractors—a $40,000 investment—admits that for the family farmer to survive, "it's either grow bigger or get out." They need energy to grow, but if it comes through in a way that blocks their ability to use new methods of farming, they feel that "it just doesn't make sense."

In March 1977, Will Mische came to a meeting of Keep Towers Out, or KTO, and asked members if they would like to try to send electricity without wires, using a method proposed in 1908 by Nikola Tesla. Virgil said sure, and volunteered his bean field as a site for the experiment.

Mische, 40, lives outside Saint Cloud, in Stearns County, has a masters degree in sociology, and works for the Minnesota State Employment Service. He had been active in the peace movement in the sixties and early seventies, and remains committed to social action. He became increasingly worried that resistance to the line was driving people to violence they did not want.

When, in February 1977, he read a newspaper article about Canadian and Russian experiments in wireless transmission of electricity using Tesla's ideas, he and his wife volunteered their time and savings to the project. He sees it as a first step to "the kind of alternative that can meet the farmers' concerns, yet provide abundant energy to help all people." He also enlisted the aid of several people of like spirit in the food cooperative movement in the Twin Cities.

Will, Virgil, and Virgil's two oldest sons worked spring and summer to build the Tesla receiver in Virgil's bean field. Their aim is to receive power broadcast from other experimenters in Timmons, Ontario, who are building a Tesla transmitter. Officials in the energy industry and Minnesota government are surprised when they hear that Virgil has allowed 7,000 feet of cable to be buried in his bean field as a ground and has erected a 60-foot tower as an antenna. They don't think it will work. "It is only one of the many things we are doing," say the resisters. "We won't ever give up, we are determined."

Often I am asked to lecture to various audiences about what it is that the farmers really want; what is really behind it all. I usually show how the resistance takes the shape of a social movement, like the black power movement, the environmental movement, women's liberation. Using models we developed studying and analyzing these other movements, I explain that the power line resistance is organized much like these other movements.

I'm lucky.



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It is segmentary, with many different groups; it is polycentric, with many leaders. It is integrated by networks, rather than by a formal, bureaucratic chain of command. The movement grows as its participants go out and recruit others, face to face. Its participants become committed—radicalized—as they take risks by standing up to established orders, as they did on Constitution Hill. The resisters legitimatize their actions and drive forward under the thrust of powerful ideas about the evils of the line and the rightness of their efforts. I show that movements like this are not simply explained away as the work of a few agitators. They become powerful enough to stop established orders and generate change.

Sure, my audiences agree. You have just restated our problem. But what is the answer? How can we deal with this in a rational manner?

To the energy industry, resistance often seems not only irrational but also selfish, even unpatriotic and irresponsible. If fighting to implement the administration's energy plan and achieve independence from imported oil and natural gas is "the moral equivalent of war," then developing the coal and lignite of the northern Great Plains is one of the holy battles. The energy industry can get the capital to build and use the machines to mine the sprawling deposits of fossil fuel, convert these to electricity in power plants near the mines, and send it by high-voltage transmission lines to tie into regional and national grids and supply the needs of farms, towns, industries, and cities. The ±400 kilovolt, direct-current line will carry electricity into the national grid from a 1,000-megawatt plant in Underwood, North Dakota. The cooperatives see it as a worthy effort, but instead of being praised it is being blocked by what they regard as the selfish action of a handful of misguided landowners.

And government is troubled. Minnesota officials feel they have a power plant and line-siting process that protects individual rights and the environment while assuring timely and responsible energy development. Both energy developers and government officials explain that the resisters have had the benefit of this state process and of every legal remedy. The resisters' lawsuits have been heard through all the state courts. After a month of deliberation the State Supreme Court denied their final appeal on September 30, 1977.

The resisters have been heard by the state legislature, which has accordingly modified legislation to protect farmland in future sitings. The governor and church officials have tried separately to negotiate settlements between resisters and co-ops through mediation. Resisters now get sizable payments for easements. Thus, officials and energy developers say, "What more can the resisters expect? They can't just say that the 'bottom line is no line.' They should now accept the conclusion that the line will be built over the land of some of them." But these officials and energy developers join many others in asking, "Will it take force to settle it? Will it be necessary to bring out the National Guard, after all?"

In trying to answer such questions, I remember how a sheriff in Stearns County explained to the press why he and his few deputies could not disperse resisters and enforce surveying and construction: "To pull guns is to be willing to use them, and the line just isn't worth this."

So I have to say, "No, force is not the answer." Warning of energy shortage is not the answer. Telling resisters that they can't stand in the way of the energy industries' means of winning the great crusade to meet America's energy needs is not the answer. Telling them that they had their day in court, participated in the decision-making process, and must accept the outcome is not the answer. At least, not now, not in this case, for these resisters. It may be for others, later. But for these resisters, it is they who are "in the right." It is they who are "fighting the moral equivalent of war." And some accept that it might become a real war. So, whose cause is the right one?

Is it that of those who decide to develop coal and lignite as the country's great black hope or of those who say, "Not over my place"? What do you do when resistance becomes as much a crusade as development? Simply scatter the minority with a whiff of eminent domain? But what is the minority? The farmers say they are protecting the basic freedoms and the food-producing farmland that we all need. The energy developers say they are protecting legal processes and the energy-providing systems we all need. Government says it is making decisions reflecting study of all the social, economic, technical, political, health, and ecological factors. And it says it is facilitating public participation so it can consider all views. Maybe what officials expect is that this participative process will achieve consensus. But the participants in this process have emerged flying the banners of their rival holy causes even higher.

Even if we could determine what is the common good and what is the majority view, we live in a society that increasingly, and almost militantly, seeks to protect the rights of all minorities. If a minority does rebel instead of conform, the established order does not know what to do.

So, I have no answer to the question, How can we deal with resistance? Answers are being sought by all involved in such disputes. The answers may be different from anything we can now envisage.

And they won't just be technical and economic answers, but moral, ethical ones as well. The resisters have added feelings and sentiment to the mechanical process of transporting energy from fossil fuels. They are telling us that the energy we use costs much more than just money. We face the dilemma together. The energy future of this country is at stake.

In the summer of 1977, top Lutheran church officials came with a local minister to visit church members who are fighting the power lines. "They really listened to our concerns," Gurvin Femrite reports. "I think they learned something. Just at the end, one churchman said, 'Of course, war doesn't solve anything.' I answered him with a question. 'But if that were the case, wouldn't we still be under English rule?' "

"What did he say to that?"

"Nothing."

Luther P. Gerlach, an anthropologist at the University of Minnesota, studies social movements, including the rise of resisters to energy schemes.

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Nature's Odd Couples

Some unusual unions have big benefits . . . until one of the partners expires

> From Nature's chain whatever link you strike,
> Tenth, or ten thousandth,
> breaks the chain alike.
>
> A. Pope,
> *An Essay on Man (1733)*

Pope's couplet expresses a common, if exaggerated, concept of connections among organisms in an ecosystem. But ecosystems are not so precariously balanced that the extirpation of one species must act like the first domino in that colorful metaphor of the cold war. Indeed, it could not be, for extinction is the common fate of all species—and they cannot all take their ecosystems with them. Species often have as much dependence upon each other as Longfellow's "Ships that pass in the night." New York City might even survive without its dogs (I'm not so sure about the cockroaches, but I'd chance it).

Shorter chains of dependence are more common. Odd couplings between dissimilar organisms form a stock in trade for popularizers of natural history. An alga and a fungus make lichen; photosynthetic microorganisms live in the tissue of reef-building corals. Natural selection is opportunistic; it fashions organisms for their current environments and cannot anticipate the future. One species often evolves an unbreakable dependency upon another species; in an inconstant world, this fruitful tie may seal its fate.

I wrote my doctoral dissertation on the fossil land snails of Bermuda. Along the shores, I would often encounter large hermit crabs that had incongruously stuffed themselves into smaller neritid snail shells. Why, I wondered, didn't these crabs—their big claw protruding—trade their cramped quarters for more commodious lodgings? Then, one day, I saw a hermit crab with proper accommodations—a shell of the "whelk" *Cittarium pica*, a large snail and major food item throughout most of the West Indies. But the *Cittarium* shell was a fossil, washed out of an ancient sand dune to which it had been carried by a hermit crab 120,000 years ago. I watched carefully during the ensuing months. Most hermits had squeezed into nerites, but a few inhabited whelk shells and the shells were always fossils.

I began to put the story together, only to find that I had been scooped in 1907 by Addison E. Verrill, master taxonomist, Yale professor, protégé of Louis Agassiz, and diligent recorder of Bermuda's natural history. Verrill searched the records of Bermudan history for references to living whelks and found that they had been abundant during



Drawn from life by A. Verrill, 1900

Land Hermit Crab

the first years of human habitation. Capt. John Smith, for example, recorded the fate of one crew member during the great famine of 1614–15: "One amongst the rest hid himself in the woods, and lived only on Wilkes and Land Crabs, fat and lusty, many months."(I hope that Raymond Sokolov will act as advocate for the land crabs one of these months. Properly seasoned, they are delicious. For the whelks, I will let others speak—although I don't doubt their nutritional value.) Another crew member stated that they made cement for the seams of their vessels by mixing lime from burned whelk shells with turtle oil. Verrill's last living *Cittarium* came from the kitchen middens of British soldiers stationed on Bermuda during the war of 1812. None, he reported, had been seen in recent times, "nor could I learn that any had been taken within the memory of the oldest inhabitants." No observations during the past seventy years have revised Verrill's concluclusion that *Cittarium* is extinct in Bermuda.

As I read Verrill's account, the plight of *Cenobita diogenes* (proper name of the large hermit crab) struck me with that anthropocentric twinge of pain often invested, perhaps improperly, in other creatures. For I realized that nature had condemned this crab to slow elimination on Bermuda. The neritid shells are too small; only juvenile and very young adult crabs fit inside them—and very badly at that. No other modern snail seems to suit the crab, and a successful adult life requires the discovery and possession (often through conquest) of a most precious and dwindling commodity, a *Cittarium* shell. But *Cittarium,* to borrow the jargon of recent years, has become a "nonrenewable resource" on Bermuda, and crabs are still recycling the shells of previous centuries. These shells are thick and strong, but they cannot resist the waves and rocks forever—and the supply constantly diminishes. A few "new" shells tumble down from



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the fossil dunes each year—a precious legacy from ancestral crabs that carried them up the hills ages ago—but these cannot meet the demand. *Cenobita* seems destined to fulfill the pessimistic vision of many futuristic films and scenarios: depleted survivors fighting to the death for a last morsel. The scientist who named this large hermit chose well. Diogenes the Cynic lit his lantern and searched the streets of Athens for an honest man; none could he find. *C. diogenes* will perish looking for a decent shell.

This poignant story of *Cenobita* emerged from deep storage in my mind when I heard a strikingly similar tale last month. Crabs and snails forged an evolutionary interdependence in the first story. A more unlikely combination—seeds and dodos—provides the second, but this one has a happy ending.

William Buckland, a leading catastrophist among nineteenth-century geologists, summarized the history of life on a large chart, folded several times to fit in the pages of his popular work *Geology and Mineralogy Considered With Reference to Natural Theology*. The chart depicts victims of mass extinctions grouped by the time of their extirpation. The great animals are crowded together: ichthyosaurs, dinosaurs, ammonites, and pterosaurs in one cluster; mammoths, woolly rhinos, and giant cave bears in another. At the far right, representing modern animals, the dodo stands alone, the first recorded extinction of our era. The dodo, a giant flightless pigeon (twenty-five pounds or more in weight), lived in fair abundance on the island of Mauritius. Within 200 years of its discovery in the fifteenth century, it had been wiped out—by men who prized its tasty eggs and by the hogs that early sailors had transported to Mauritius. No living dodos have been seen since 1681.

In the August 26, 1977, issue of *Science*, Stanley A. Temple, a wildlife ecologist at the University of Wisconsin, reported the following remarkable story. He, and others before him, had noted that a large tree, *Calvaria major*, seemed to be near the verge of extinction on Mauritius. In 1973, he could find only thirteen "old, overmature, and dying trees" in the remnant native forests. Experienced Mauritian foresters estimated the trees' ages at more than 300 years. These trees produce well-formed, apparently fertile seeds each year, but none germinate and no young plants are known. Attempts to induce germination in the controlled and favorable climate of a nursery have failed. Yet *Calvaria* was once common on Mauritius; old forestry records indicate that it had been lumbered extensively.

Calvaria's large fruits, about two inches in diameter, consist of a seed enclosed in a hard pit nearly half an inch thick. This pit is surrounded by a layer of pulpy, succulent material covered by a thin outer skin. Temple concluded that *Calvaria* seeds fail to germinate because the thick pit "mechanically resists the expansion of the embryo within." How, then, did it germinate in previous centuries?

Temple put two facts together. Early explorers reported that the dodo fed on fruits and seeds of large forest trees; in fact, fossil *Calvaria* pits have been found among skeletal remains of the dodo. The dodo had a strong gizzard filled with large stones used to crush tough bits of food. Secondly, the age of surviving *Calvaria* trees matches the demise of the dodo. None has sprouted since the dodo disappeared almost 300 years ago.

Temple therefore argues that *Calvaria* evolved its unusually thick pit as an adaptation to resist destruction by crushing in a dodo's gizzard. But, in so doing, they became dependent upon dodos for their own reproduction. Tit for tat. A pit thick enough to survive in a dodo's gizzard is a pit too thick for an embryo to burst by its own resources. Thus, the gizzard that once threatened the seed had become its necessary accomplice. The thick pit must be abraded and scratched before it can germinate.

Several small animals eat the fruit of *Calvaria* today, but they merely nibble away the succulent middle and leave the internal pit untouched. The dodo was big enough to swallow the fruit whole. After consuming the middle, dodos would have abraded the pit in their gizzards before regurgitating it or passing it in their feces. Temple cites many analogous cases of greatly increased germination rates

for various seeds after passage through digestive tracts of several animals.

Temple then tried to determine the crushing force of a dodo's gizzard by making a plot of body weight versus force generated by the gizzard in several modern birds. Extrapolating the curve up to a dodo's size, he estimates that *Calvaria* pits were thick enough to resist crushing; in fact, the thickest pits could not be crushed until they had been reduced nearly 30 percent by abrasion. Dodos might well have regurgitated the pits or passed them along before subjecting them to such an extended treatment. Temple took turkeys—the closest modern analogue to dodos—and fed them *Calvaria* pits, one at a time. Seven of seventeen pits were crushed by the turkey's gizzard, but the other ten were regurgitated or passed in feces after considerable abrasion. Temple planted the ten seeds and three of them germinated. He writes: "These may well have been the first *Calvaria* seeds to germinate in more than 300 years." *Calvaria* can probably be saved from the brink of extinction by the propagation of artificially abraded seeds. For once, an astute observation, combined with imaginative thought and experiment, leads to preservation rather than destruction.

With this column, I begin the fifth year of "This View of Life." I said to myself at the beginning that I would depart from a long tradition of popular writing in natural history. I would not tell the fascinating tales of nature merely for their own sake. I would tie any particular story to a general principle of evolutionary theory: Irish elks to extinction; decoy "fish" on a clam's rear end to the problem of perfection; flies that eat their mother from inside to adaptation. But this column has no message beyond the evident homily that in our complex world things are connected to other things—and that local disruptions have wider consequences. I have only recounted these two, related stories because they touched me—one bitterly, the other with sweetness.

Biologist Stephen Jay Gould's most recent book is Ever Since Darwin: Reflections in Natural History.

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Tovil: Exorcism by White Magic

by Michael M. Ames

photographs by Yvonne Hannemann

Instead of bell, book, and candle, Sri Lanka's Buddhists use dance, song, and theater to cure demon-caused illness

Legend has it that when Buddha first visited Sri Lanka (formerly Ceylon), he struck a bargain with the demons. Their karma is to persecute humans, causing illness and misfortune. But once appeased, the devils must desist. The duty of the benevolent gods, long ago converted by Buddha's teachings, is to use their superior power to insure that the demons keep their word.

And so Buddhists of Sri Lanka believe that when someone falls ill and finds no relief in Western or ayurvedic (primarily herbal) medical treatments, a demon (*yakā*) may be the cause. The patient or his family will then seek the advice of a priest (*yakädurā*) who specializes in the appeasement and exorcism of *yakās* and of less dangerous ghosts (*pretas*). If the priest diagnoses a spirit attack, he will prescribe a *tovil* ceremony—a long, elaborate ritual exorcism, involving as much as thirty hours of drumming, dancing, and chanting.

On February 12, 1978, at the American Museum of Natural History, a troupe from Sri Lanka will perform *tovil,* the exorcism ceremony of ritual chanting, dancing, and drumming. Tickets for the performance, which starts at 3:00 P.M. in the auditorium, may be purchased by the general public for $5.50 each at the Museum or by calling (212) 581-1105.

For a complete schedule of the troupe's February and March tour of nine other United States cities, contact the sponsor, The Performing Arts Program of the Asia Society, 133 East 58th Street, New York, N.Y. 10022.

Tovil is part of a large collection of magical practices that aid troubled Sinhalese Buddhists when all else fails. Many regional varieties of these ceremonial arts exist, but there are only three basic types: exorcism of ghosts and demons, propitiation of planetary deities and astrological powers, and veneration of so-called Hindu gods, who, the faithful say, predate Buddha and have nothing to do with Buddhist teachings or practice.

Officially, Buddhists seek salvation from life's suffering through the cycle of rebirths and ultimate redemption from this cycle through purity of thought and deed. But this goal is difficult to understand and even more difficult to attain, requiring perhaps many thousands of rebirths. To cope with daily life, the faithful require more immediate solace. Sinhalese Buddhism faces the dilemma of all redemptive religions: it offers salvation from this world while obliged to remain very much a part of it. Although not a formal part of Sinhalese Buddhism, the three ceremonial systems that console through magic are its complement.

In Sri Lanka's southern lowlands, where I conducted most of my research, the three systems—and the offerings, ceremonies, and priestly mediators they require—are ranked according to the spirits they address. The law of karma dictates that all spirits have been reborn in their present forms because of previously earned merit or demerit. A virtuous person may be reborn as a high deity, while a glutton may first become a *preta* of the deceased and then a ravenous demon. At the top of the spiritual scale are deities—almost always benevolent—of varying powers and talents, who aspire to become future Buddhas. Planetary and astrological gods rank somewhere in between these deities and the consistently malevolent demons and ghosts at the bottom of the hierarchy.

Tovil dance drama is therefore the lowest category of magic ceremony. Only temporary shrines are constructed for its purposes, for demons are certainly not welcome permanently, and appeasement takes the form of impure offerings, such as a cock. The professional status of *yakädurās* contrasts with that of *kapurālas,* priests who pay homage to benevolent deities. *Kapurālas* may be permanently attached to temples, where they can enjoy a guaranteed income, regular hours, and the psychic reward of performing meritorious acts worthy of pious Buddhists. Chasing out demons by means of *tovil* is necessary work, but it lacks virtue. *Yakädurās* perform genuinely therapeutic services and may come from any social caste, but because they deal with evil, they may be more feared than respected.

Nevertheless, a *yakädurā* requires more knowledge than other priests. During his apprenticeship, he becomes a master of spells and charms, the principal means of controlling *yakās* and *pretas.* Once he becomes adept at charming, he recruits a troupe of assistant magicians, dancers, and drummers to work with him. He must memorize many charms, songs, and ballads, and master intricate and frenzied dance routines. In addition to this

As a tovil *ceremony begins, a dancer whirls to drumbeats and chants.* Tovil *songs and dances honor Buddha, appease demons, and appeal to benevolent gods who hold sway over evil spirits.*





magical lore, the demon priests I knew were as conversant with Buddhist theology as most village monks. These *yakädurās* were also familiar with deity rituals and ayurvedic medicines. While higher priests can ignore lower systems, *yakädurās* need some knowledge of all religious phenomena.

Besides knowledge, a *yakädurā* needs strength to endure his arduous life. If called, he must be willing to break his sleep night after night, for he treats people in pain who need and demand quick relief. For a whole night's work, he usually earns only five to forty rupees, depending on the income of the patient's family and the seriousness of the illness. The priest may not be solicited again for more than a month.

Indeed, the frequency of *tovil* curing ceremonies has declined during the last century. Denounced as idolatrous superstition by Christian missionaries and Western rationalists who dominated the development of modern education in Sri Lanka, *tovil* has faced increasingly



While the patient, far left, sits quietly, the chief priest, left, prays over an offering of flowers in an elaborate basket. He will bless both patient and offering with an igaha, *a magic wand made of palm leaves, below. The patient's family, under the priest's direction, made the basket, the wand, and other ceremonial objects.*

stiff competition from ayurvedic, homeopathic, and allopathic medical systems; Buddhist reform movements; and the growing popularity of the Hindu god Kataragama. Because of changes in the economy, demon priests are hard pressed to earn a decent living. One well-known *yakädurā* will be the last in his family; his son is a bus conductor and has no plans to pursue his father's profession. People who work for wages seem to have less time and money to devote to *tovil* entertainments, and many of the masks used by *tovil* dancers have disappeared into European and American collections.

Nowadays the Sinhalese profess skepticism about their world of countless demons and ghosts. Nevertheless, one Sinhalese said to me, "I don't believe in all those demons, but I can't be sure that they don't believe in me." When people fall ill, they may seek other remedies first, but, in the spirit of Pascal's wager, they grant that the demons are worth a try.

A *tovil* ceremony focuses on five important *yakās,* making special allowances for other notable demons and for the hordes of lesser demons and ghosts who follow behind. Though symptoms overlap considerably, and priests vary in their diagnoses, each *yakā* is nominally associated with specific diseases. These are either hysteria, in association with hallucinations and aberrant behavior, or physical disorders, including broken bones, linked with psychological distress. For example, *Rīri Yakā,* the blood demon, who assumes a variety of human and animal forms in order to dig up fresh graves and devour bodies or suck their blood, is thought to cause fevers, stomach pains, headaches, and hysteria, and is associated with diseases and injuries that result in loss of blood. *Mahasōna Yakā,* the "great cemetery demon," lies in wait in graveyards for people burying their dead. He also lurks at four-corner inter-



sections, slaughterhouses, and lonely places. He too takes on several forms, has thirty thousand demonic assistants at his call, and causes cholera, smallpox, and dysentery. The third arch demon, *Hūniyan Yakā* is one of the most powerful and his *tovil* is one of the most elaborate.

Kalu Kumāra, known as the "black prince," and his female form, *Mohini Yakkhini,* are the incubus and succubus of Sinhalese mythology. The first causes menstrual disorders in women and young girls, troubles during pregnancy, and erotic dreams. The succubus visits young bachelors at night, causing nocturnal emissions. She drives young men to distraction or hysteria: her victims may run wildly into the jungle or shout and scream for no apparent reason. For such cases, priests have been known to prescribe marriage as well as exorcism.

The fifth important *yakā* is *Mahakōla Sanniya Yakā*, the demon of delirious and convulsive states, the particularly hideous and powerful leader of the eighteen *sanni,* personifications of the terrible maladies they cause. During the *Sanniyakuma tovil* ceremony, masked dancers impersonate *Mahakōla* and his eighteen assistants. The *kōla* mask is often elaborate, depicting miniatures of the *sanni.* The *sanni* masks, on the other hand, are crudely carved and brightly painted, meant to depict the illness each demon brings. One mask has sightless eyes, while another has a cobra, symbol of deafness, wrapped across one side. During a *tovil,* all eighteen, although cited in song, never actually appear; five to seven are usually shown, representing mainly psychological disorders. Sinhalese seem to feel that fear causes disease. If a patient's fears are calmed, so that he finds peace and happiness in following the Buddha's teachings, his health will be restored. By alleviating mental distress, *tovil* enables Buddhists to concentrate on meditation and growth in virtue.

In one version of tovil, *a dancer, below, dresses as the demon being exorcised. At right, he dances with flaming torches. Far right, the patient is carried in a litter to a burial ground. To fool the patient's demon persecutors, a dummy representing him will be cremated before high noon.*









When a *yakädurā* diagnoses demon persecution, the patient's family may opt for a *tovil*. Once this commitment is made, it must be honored. The patient's horoscope is consulted for an auspicious date and fees established for the priest and his assistants. The wealthier the family, the more elaborate the ceremony should be; therefore, the larger the troupe, the higher the price. The simplest possible *tovil* would involve only one priest and could be conducted in privacy inside the patient's house. But most *tovils* are held in a courtyard of the family home and call for at least one drummer, several dancers, and perhaps a master of spells, usually the leader of the troupe, whose members have probably worked together for years.

The *tovil* audience has its own role. The ceremony is always a family affair, an occasion for friends and relatives to gather and demonstrate emotional and financial support for the patient. Since the *tovil* begins at dusk and continues at least until dawn or noon of



At about 3:00 A.M. the troupe stages a series of bawdy comic sketches. Left: A masked dancer represents a disease-bearing demon as a clown. Right: Before an ornate palm leaf shrine, another dancer describes tovil's *origin, a story that, throughout the ceremony, holds the audience's attention.*

the following day, family members and retainers must gather food for the expected well-wishers. The morning before the ceremony, the family, under the chief priest's direction, weaves and folds banana stems and young shoots of palm leaves into elaborate shrines and offering containers.

In front of the house, space is cleared for the ceremony itself and for observers. The patient is laid out at one end on a cot or mat, opposite a large gatelike palm leaf structure through which the demons must come. Although the *tovil* ritual will focus on just one major *yakā*, each important devil and some *pretas* must be appeased, and so small shrines and offering baskets are also set up.

By late afternoon, the chief priest and his troupe arrive and put on their costumes. Each dancer wears several short white-and-red skirts, one over the other, a short tight jacket, a wide white or red sash, anklets adorned with bells, makeup, and sometimes a turban. While dancing, each may hold tufts of young coconut leaves and later in the evening take up burning torches soaked with oil. The dances begin slowly and solemnly, but grow progressively more lively, sometimes led by the drums and sometimes counterpointing them. Dancing and commentaries interlace singing and chanting of powerful mantras. As costumes and torches flash, bells jingle, and drums beat rhythmically, performers' and spectators' excitement steadily mounts.

Tovil's most dramatic episode, the *maha samayāma,* takes place just after midnight. One dancer, holding burning torches in his mouth and hands, dances with such frenzy that the audience is led to believe that he goes into trance. Most *yakädurās* actually avoid trance because they have no wish to be possessed by the demons they are attempting to exorcise. But patients, at least those driven insane (*pissu*) by demonic possession, may genuinely fall into trance at this point. Some have been known to fake trance. Usually unmarried and sexually frustrated young men and women become *pissu*—to gain attention, to excuse past indiscretions, or to elicit parental permission to marry. Villagers enjoy trying to detect a faker. They watch the patient's eyes—they should be glazed—and dancing to judge whether he exhibits a demon's expertise.

A possessed patient—or rather, the demon in the patient's body—will be made to dance about the performance arena. Once the demon has enjoyed himself and the patient is completely exhausted, the priest bargains. Before consenting to depart, the *yakā* may demand offerings and a second dance.

After the tense pitch of the *maha samayāma,* the *tovil* rushes to conclusion with a bawdy comedy routine. The crowd and the patient are vastly entertained; by *tovil*'s end, bloodthirsty demons have been reduced to laughable impotence. The procession of the eighteen *sanni* is particularly comic. These demons, responsible for various illnesses, are presented as ridiculous, retreating buffoons. As they depart, so do the patient's symptoms. One *sanni* may act totally confused, mistaking a cat for a buffalo or reciting prayers in gibberish. Another has diarrhea and speaks in obscenities.

In *tovil,* entertainment is inseparable from exorcism. Colorful songs and dances honor the gods and placate demons; they also entertain assembled guests and distract the patient. By means of words, gestures, and masks, priests confront the sufferer with concrete images of *yakās* and *pretas* who are vanquished before his eyes. While propitiating harmful spirits, a priest is also trying to change the sick person's mental disposition.

Tovil is simultaneously a social event for relatives and friends, ritual drama, therapeutic catharsis for the patient, and theological discourse. A major *tovil*'s many parts are basically a simple formula, repeated for each important *yakā* to emphasize the lowly place of demons in the spiritual hierarchy. Officiating priests first pay homage to the Buddha, whose teachings and moral power are supreme. Next the priests appeal to the mercy of the benevolent deities who hold sway over demons. Finally, the demons are appeased with offerings and obliged to stop harassing the patient.

Hence the most monstrous ghosts and demons are shown as subject to the law of karma, the teachings of Buddha, and the power of the gods. As demons can be combatted and subjugated, so can life's daily problems. *Yakās* and *pretas* symbolize the impurities—greed, anger, jealousy—humans must purge themselves of before they can win release from suffering. *Tovil* not only provides therapy for psychosomatic disorders, but also dramatically reaffirms the world view of Buddhism at its popular, grass roots level. □



Ibex in Israel

by Len Aronson

photographs by Gail Rubin

Under strict protection, these biblical goats are shifting through their seasonal home ranges in increasing numbers

The oasis of Ein-Gedi shimmers in the heat on the western flank of the Dead Sea. At 1,302 feet below sea level, this is the lowest area on the surface of the earth. In this part of Israel the crags and steep canyons of the Great Rift Valley are home to the Nubian ibex, an extremely agile wild goat that is well adapted to extreme temperatures and sparse vegetation. The Ein-Gedi Nature Reserve, which comprises most of the springs and streams of the oasis, is a particular haven for these biblical animals.

The Nubian ibex (*Capra ibex nubiana*) is a subspecies that is distributed in Israel from the northern shore of the Dead Sea along the rift valley as far south as Elat. Small herds exist in parts of the Negev highlands, and limited numbers can be found in the Sinai Peninsula. Nubian ibex also still survive in Syria, Jordan, Egypt, and Saudi Arabia but their numbers are held down by herds of Bedouin sheep and goats, which present severe competition for ibex, especially in drought years.

The distribution of ibex is limited primarily by the availability of water: ibex need to drink every few days. Their diet is heavy in halophytes (plants with a high salt content), which may explain their dependence on drinking water. A wide variety of plants grow within the Ein-Gedi oasis and ibex feed on most of them. In addition to the desert-adapted halophytes, ibex also favor the savanna-type trees of the area, such as the toothbrush tree, the horseradish tree, and the Christ's-thorn tree. When there is sufficient rain in winter, water holes form in the surrounding canyons and wadis and the ibex can range farther from the oasis.

Ibex are normally browsers, but if sufficient grass cover exists, they prefer to graze. They begin to feed with the first light of day, and during the average thirteen hours of daylight, they spend about half the time eating, moving from one food source to another. During the hottest hours, the ibex rest and ruminate. At sunset they climb to a safe sleeping place for the night.

In drought years, however, ibex may continue to feed after dark or they may move up to their sleeping spot at sunset and come down to eat in the middle of the night. The presence of a tapetum in their eyes indicates an adaptation for night vision. The tapetum insures that light coming into an eye has two chances of stimulating the visual cells, instead of only one as in the eyes of most diurnal mammals.

With the exception of the Red Sea coast, the Dead Sea area has the highest summer and winter temperatures in Israel. Ibex are mainly diurnal and much of their feeding is done under very hot and arid conditions, but they are well suited to do so. Their shiny summer coat is an important factor in keeping body temperature down by reflecting solar radiation. The base of each hair is black and so is the skin, preventing absorbtion of harmful ultraviolet rays. Movement during the hottest part of the day is minimal, and much of the heat load is dissipated through panting.

Ibex are gregarious and are normally found in socially structured groupings that allow for an orderly daily routine, with harmful fighting kept to a minimum. Larger males tend to band together and have few social interactions with females and younger males. This separation appears to be caused by yearling females remaining within their mothers' home range, and by the tendency of young males to seek social relationships with other males of their size and age group. As they get older, males vacillate between female–young groups and intermediate male groups (three to five years old). At the age of six or seven, they finally join up with one of the large male groupings.

A well-defined hierarchy exists within the male group social structure. Those who dominate are large bodied and large horned. Among the females there is also a hierarchical structure, but this is little understood. Since the maximum size of a female's horn rarely exceeds that of a yearling male, females are dominated by males two years old and up.

Dominant males secure their positions in the hierarchy by serious fights in which the force of a blow can snap a horn. Usually, the loser is not physically banished, although in some cases he may temporarily leave the home range. Once established, the hierarchy is constantly reinforced by displays and nonserious fighting. Almost all of these interactions take place between individuals that are more or less equal in size. Preparation for these dominance fights starts at an early age, with two-week-old kids practicing fighting behavior. The most characteristic behavior pattern of dominant males is a horn threat—lowering the head in a men-

Beyond reach of predators, a herd of Nubian ibex negotiate a trail on a sheer cliff of the Great Rift Valley in Israel. Their spongy hoofs help them grip the rocks.





acing position and preparing to butt. This is usually enough to induce subordinate behavior in smaller males and females. In general, males that reach the alpha position within a herd maintain it for only two or three years. Younger males can therefore rise in the hierarchy and eventually have an opportunity to mate.

The dominant males do most of the courting and mating during the rutting season, but there is a definite distinction between dominance and leadership. This is well illustrated in mixed herds. The males in such herds dominate the females in matters of food and resting spots; but when the herd is in movement, one of the older females invariably takes the lead.

There is a high mortality rate among males seven years and older, and there are almost no instances of males living more than twelve years. Old males tend to walk alone rather than in a herd or small group. They are quite heavy, more than 175 pounds in some cases, and not as agile as younger males and females. This makes them easy prey for leopards, which are increasing in the Dead Sea region.



The desert race of leopard, formerly thought to be extinct in Israel, is an important factor in keeping the ibex population down. An examination of dozens of leopards' scats showed that ibex make up the main part of their diet. The reaction of ibex to the presence of a leopard is interesting. Ibex exhibit a great deal of curiosity. Even when fleeing danger, they will stop and turn around to look at their pursuer. On one occasion I observed a group of about twenty ibex that had



Just prior to the rut, several males within a herd "present" their horns to one another (top, preceding page). This behavior helps to establish rankings in the dominance hierarchy, although the alpha male position has already been decided. If two contestants have horns of similar size, neither may back off and they may exchange butts intense enough to snap a horn. A breeding male (bottom, preceding page) performs a lip curl caused by smelling the urine of an estrous female. Two juveniles (left) imitate the adult copulatory posture. A dominant male, below, approaches a female resting from his attentions.



discovered the presence of a leopard. They began to close in and to stare at him in a fashion similar to that of mobbing in birds. They all showed nervous reactions—raising their tails in the air, stamping their forelegs, and whistling nervously. They continued to close in until they were about forty-five feet from the leopard, which finally got up and moved away.

On another occasion, my dog was the object of ibex curiosity. In the evening twilight, my dog and I were sitting near one of the springs in the oasis. A group of ibex sighted the dog and began to move in until they were within six feet of us. Being a well-disciplined animal, the dog sat quietly. However, the tension became so great for her that she finally broke for the ibex. In a matter of seconds they reached a nearby cliff and were out of danger. Their spongelike hoofs are able to grip rocks where a single slip could mean death or, at best, severe in-

jury. This ability is the best defense of the ibex, although large males are able to inflict terrific blows with their three-foot-long horns.

Ibex are not territorial animals in that they do not defend areas to prevent trespassing by other individuals. The area that ibex cover in their daily activities is their home range. According to the time of year and the climatic conditions, they can be found in one of their seasonal home ranges. They are loyal to these home ranges and will return to them year after year unless some untoward circumstance prevents their doing so. Summer, winter, prerut, rutting, and lambing home ranges are used in sequence by the appropriate animals.

Movements from one home range to another are probably learned from older individuals. In a drought year the movements are restricted to those areas where there is suitable forage. This applies in particular to the movements of pregnant and lactating females. For many females, the summer and winter home ranges coincide in a drought year. The largest males show the most distinct movements from one home range to another, even during drought years.

Ibex show little variation in their ordinary behavior most of the year. But during the prerut and rutting



The male at right is in prime mating condition and will be an active breeder for about three years. The old male, below, will be easy prey for a leopard.



periods there are marked changes in the males, and from about July, males begin to show their rutting colors. They drift into a special prerut home range that is used every year. The oldest and most dominant males usually appear last. They become very sluggish and at times are still asleep on their sides at eleven in the morning. The sluggishness may be a means of conserving energy for the strenuous rutting to follow. During the hot part of the day, there is little interaction between individuals, but toward nightfall fighting begins to break out.

A characteristic prerut activity is the "huddle." Several males come together in a circle, their heads toward the middle, and present their horns to one another. Individual fights may break out, but the dominant male usually does not participate. His dominance is already accepted by the rest of the group.

At about the time of the autumnal equinox, the male prerut herds break up and the members go off in search of receptive females. The posture that males take at this time is curious. They bend their heads back over their shoulders and curve their tails up over the backbone, exposing a white rump patch to the fullest. The body is taut and held close to the ground. In this manner the male will walk after a female for hours. At times, the male will perform a kind of dance, short-stepping backward and forward in relation to the female. The dominant males don't let subordinates come close to any receptive females.

Females show a quiet heat, not forcing themselves on the males in any manner. The behavior of a courting male is very cautious, which apparently keeps the female from running off into an area where there are other large males. The male is constant in his mating pursuit and hardly eats. The female, however, continues to browse, paying scant attention to her suitor. One means that the female has of diverting an ardent male's attention is to urinate. The urine, probably containing breakdown products of hormones, causes the male to lip curl (flehmen). While he is doing this, the female can move a little distance away and rest.

Mating occurs in October, usually at night when the females are fully receptive after a full day of courting. Prior to mounting, a male gives a series of whistles and becomes quite aggressive toward the female. He then mounts her, with intromission lasting only about three seconds. There is no pair formation among ibex; once mating is accomplished, the male looks for other receptive females.

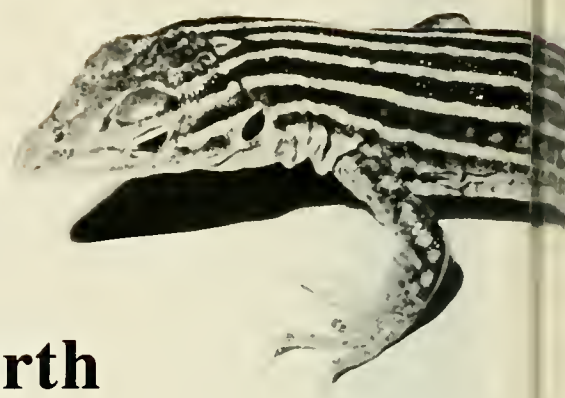
The rutting season is short, about one month. Males remain in the vicinity of the females for one to three months afterward; the older, more dominant males are first to leave for their winter home range. Toward the middle of March the females begin to give birth. They leave their kids of the previous year and climb to more inaccessible cliffs to give birth. There is very little forage in these areas, but they are difficult for predators to reach.

Ibex kids are physically precocious. They are born with their eyes open, and within minutes they attempt to rise up on their legs. Within twenty-four hours they can walk, but they don't run and jump well. At the end of forty-eight hours they are running and jumping and even doing aerial splits. When they are one week old they can negotiate almost any place on the cliffs that their mothers can. By two weeks they can jump more than three times their own height. Since the kids are so quick in their development, there is apparently no need for the mother to eat the afterbirth (as is common in many ungulates) to reduce the chances of her kid being discovered by predators.

After several days of being alone, during which mutual imprinting takes place, mothers with new kids join together to form nursery bands. The initial bond prevents the kids from losing their mothers and going to some other female. When there is no direct line of sight between mother and kids, they seek one another by vocalizing. The sounds they emit are similar to the "baaing" of sheep. Once mother and kid see one another, the kid will stoop down and begin to suckle. While it is suckling, the mother will in many instances smell the kid's anal gland —apparently positive proof of identification. The kids, which have been making nibbling movements with their lips and mouth since they were two days old, will lick, smell, and chew on plants, but not until the age of one week do they actually begin eating and digesting small amounts of vegetation. The weaning process is gradual. Mothers never butt or charge at their kids to prevent them from suckling. This behavior on the part of the mother assures that the kid will not be forcibly ejected from the framework of the group.

Kids and mothers maintain a close relationship until the mothers give birth again the following year. The parent continues to groom her offspring, and sleeps next to it up until the day that she goes to parturate. The yearlings then join up with the nursery bands. When the mother and her newborn kid return from their seclusion, other females and their kids, along with the juveniles, organize into large herds and move to their summer home ranges—continuing their annual behavioral cycle.

Because, throughout history, ibex were much sought after by man, they came close to extinction in several areas. The Romans enjoyed ibex fighting as a spectator sport. During the Middle Ages, the animal had a magical reputation in Europe. The ibex became a walking pharmacy: its blood was considered a cure for callouses; hair balls, composed of hair, resin, pebbles, and other indigestible items that formed in the animal's fourth stomach, were used to treat cancer; rings made of ibex horn were worn to prevent disease; and ibex feces were prescribed as a remedy for gout and tuberculosis. The Bedouins of the Judean desert once hunted ibex extensively for their fine-tasting meat, but strict protective laws, prohibiting the hunting of ibex and creating a network of preserves, has changed the outlook for these superbly adapted arid-land creatures. They now thrive in most parts of their former range in Israel, and oases such as that at Ein-Gedi are interlaced with their trails. □



The Value of Virgin Birth

by Charles J. Cole

Some female lizards can reproduce without mating, enabling them to quickly establish new colonies that are devoid of males

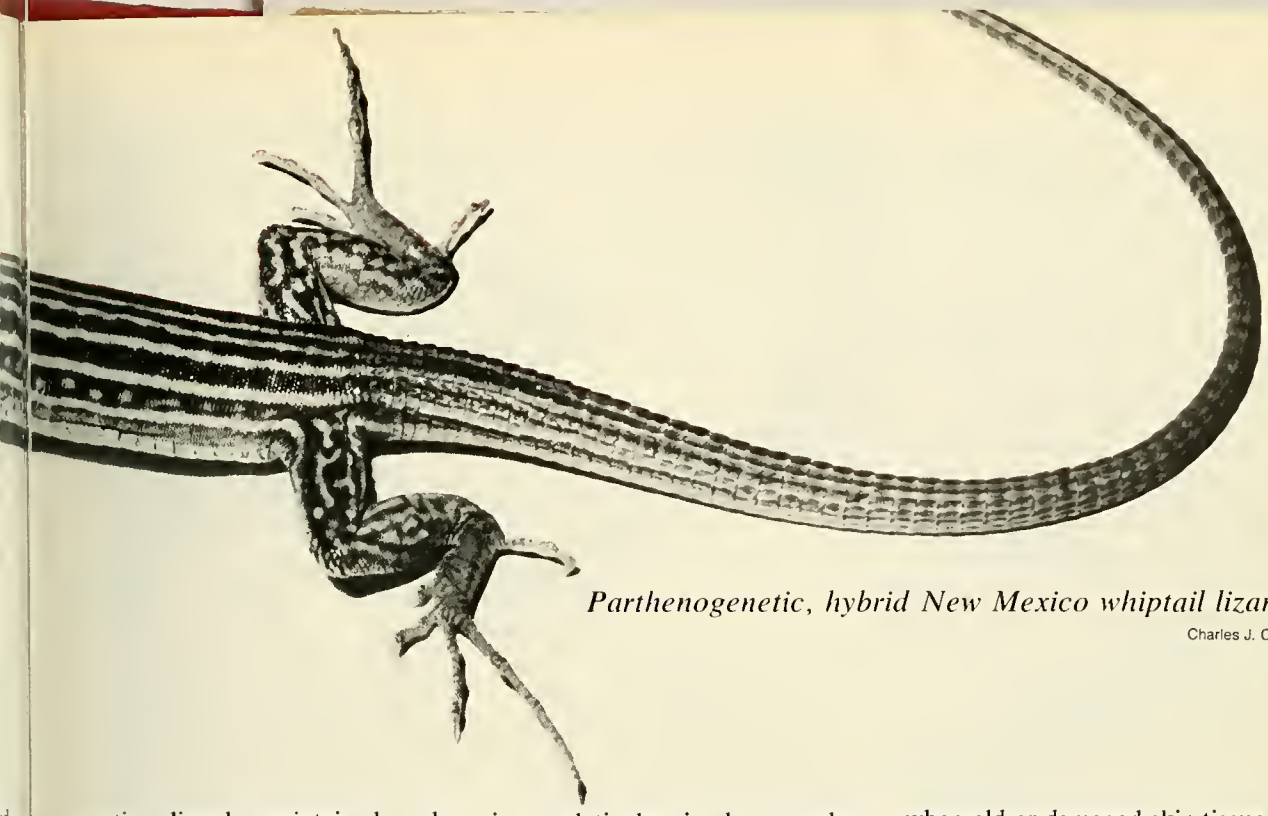
Biologists studying reptilian reproduction had always assumed that, as in humans, it takes two to tango. This assumption was shattered about twenty years ago when a herpetologist, just returned from a field trip, sorted out samples of preserved lizards and discovered that for some species there were only females. He could have shrugged this off with the thought that the males had simply been overlooked or missed while collecting. But he and a few colleagues dared to think that the samples reflected a real absence of males, and the study of this phenomenon began in earnest.

More than two dozen species of reptiles that can reproduce without males are now recognized. These exceptional vertebrates are frequently referred to as "all-female" or "unisexual" species. The big differences between these reptiles and related bisexual species are that in all-female species each normal adult is a virgin that produces offspring independently, and all offspring are females. This means of reproduction is known as parthenogenesis—the development of unfertilized eggs. Such procreation differs from that of the few all-female species of fish and salamanders, which only reproduce after breeding with males of closely related species.

Natural parthenogenesis has been known to biologists for a long time from the many species of invertebrates that consist only of females (for example, some weevils and crustaceans). In other invertebrates, such as social wasps and bees, males are produced by development of unfertilized eggs (all fertilized eggs develop into females). Although such observations suggested several intriguing questions of basic importance to reproductive and developmental biology, vertebrate biologists historically had taken comfort from the thought that natural parthenogenesis was peculiar to a number of plants and to "simpler," invertebrate forms of animals, not something to be concerned with too seriously among the vertebrates.

The first published report strongly indicating that some species of reptiles reproduce parthenogenetically was published in 1958 by Ilya Darevsky at the Zoological Institute, Academy of Sciences of the USSR. Darevsky could find only females in some populations of Armenian lizards and discovered that these could produce offspring in isolation from males of any species of lizard. Prior to Darevsky's report, Sherman A. Minton at the Indiana University Medical Center and Richard G. Zweifel at the American Museum of Natural History were puzzling over the absence of males in certain samples of whiptail lizards from the southwestern United States. Darevsky's report put their observations into sharp focus, and since then, about a hundred papers concerning all-female species of reptiles have appeared in the literature. In addition, some species of lizards have been discovered that have bisexual populations at some localities and unisexual populations at others.

Much of the evidence for parthenogenesis in reptiles had been circumstantial. The initial hypothesis stemmed from the apparent absence of males in certain populations. But how could one be sure this was not a matter of sampling error, even though some of the samples were extensive? Additional collecting might reveal males. Or, if males of these species were truly nonexistent, how could the possibility that the females breed with males of other species be ruled out? The most direct evidence could be derived from studying



Parthenogenetic, hybrid New Mexico whiptail lizard

Charles J. Cole

captive lizards maintained under controlled conditions, but year after year, attempts to raise these animals in several laboratories failed to establish perpetuating colonies. In 1971, T. Paul Maslin at the University of Colorado reported obtaining a few parthenogenetically produced embryos and offspring from laboratory-raised whiptail lizards, but this triumph was marred by the premature death of most of the animals and no continuing colonies resulted.

Early failures to raise all-female species of lizards in the laboratory did not necessitate rejecting the hypothesis that parthenogenetic reproduction occurred in nature. Before the hypothesis could be thoroughly tested, the vital requirements of laboratory hatchlings had to be determined so they could reach adulthood in good health and with consistent reliability.

This problem was solved recently at the American Museum of Natural History. The premature deaths of captive lizards, which had plagued earlier efforts, including ours, apparently resulted from a vitamin D deficiency and inadequate metabolism of minerals. Providing the lizards with essential radiant energy and nutrients has corrected the problem. Today, raising parthenogenetic whiptail lizards is a relatively simple procedure.

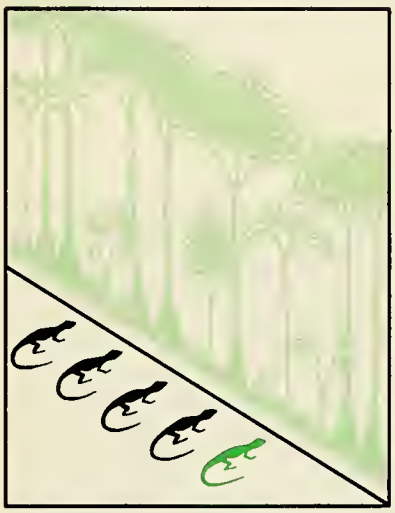
Successful colonies were started with a few adult, female Chihuahua whiptail lizards captured in New Mexico. These females were maintained in total isolation from males of any reptile species. Eggs deposited in the laboratory by the field-captured lizards produced only female offspring. At the age of about one year, our laboratory-hatched virgin females began laying viable eggs. These eggs also hatched and produced all-female offspring essentially identical to their mothers, even to having the same chromosome complements. Our colony is now into its fourth generation of all-female lizards hatched and raised in complete isolation from males.

How can parthenogenetic lizards produce viable eggs, which have complete sets of chromosomes and balanced sets of genes, even though they are not fertilized? In bisexual species, each typical body cell contains two complete sets of gene-carrying chromosomes. One set is inherited from the mother and one from the father. When the cell prepares to divide into two daughter cells, each chromosome replicates itself and the daughter cells receive a copy of both sets of chromosomes. This occurs during normal growth and development, such as when old or damaged skin tissue is replaced. However, cell division is different when eggs and spermatozoa are produced in the gonads. Consequently, a normal egg or sperm receives only one copy of each chromosome. At fertilization, when egg and sperm unite, the presence of two complete sets of chromosomes and genes is restored. It appears that parthenogenetic lizards produce eggs in a fashion that provides each normal egg with a copy of all chromosomes present in a typical body cell, instead of only half. The eggs are genetically complete.

Scientists are beginning to understand how all-female species of lizards came into being and why they survived. Parthenogenetic reproduction evolved from bisexual species, and this occurred several times, independently, among different kinds of lizards. It survives in various lizard populations for different reasons, depending upon ecological conditions.

For example, *Lepidophyma flavimaculatum* is a tropical lizard that occurs at markedly low densities in forested areas of Mexico and Central America. But these lizards thrive along the edges of forests or where trees have been disturbed or locally destroyed. At most localities, populations consist

Some species of tropical lizards have both bisexual and all-female, or parthenogenetic, populations. In forests, which cover much of their range, the lizards occur at low densities because such habitat is suboptimal. All populations of these lizards thrive, however, in forest-edge or disturbed habitats. Because these habitats are in rapid transition, a mechanism for rapid and efficient colonization would be advantageous and may explain the presence of parthenogenetic females.

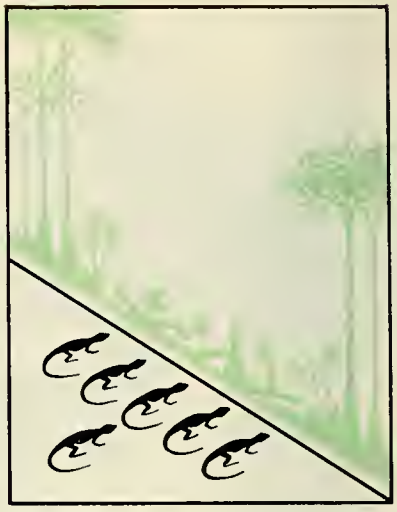


A representative population of such a lizard (above) is stylistically depicted at a low density in its suboptimal forest habitat. The black lizards are bisexual; the green individual is a female carrying the trait for parthenogenetic reproduction. No percentage or physical proximity is implied. A frequency for this trait has not been established other than that it is rare. Nor is it known whether this type of variation or mutation is recurrent or whether it is always present at some low level.

BISEXUAL



A storm has knocked over a few trees in the forest. The resultant microhabitat differs from conditions within the forest proper and is optimal for these lizards. Bisexual lizards need a minimum of two individuals of opposite sex (or a gravid female) to reach the area, meet, mate, and produce offspring to establish a colony.

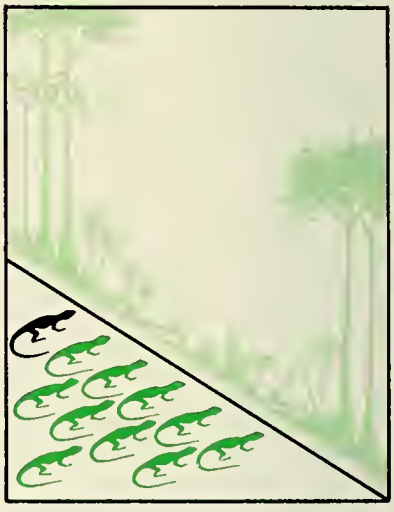


The fallen trees provide cover. Insects and other prey associated with the decay of wood furnish a plentiful food supply. And since more sunlight reaches the ground, the lizards can thermoregulate more efficiently. Because of these optimal conditions, the bisexuals have built up a higher density than a forest population.

UNISEXUAL



In the same situation, only one parthenogenetic female need find her way into the disturbed habitat in order to found a colony. (The bisexual lizard represents those individuals that have not dispersed out of the forest.) An individual's ability to take advantage of the resources in this area is not related to mode of reproduction.



The parthenogenetic colony has outproduced the bisexuals over the same amount of time. All offspring are identical copies, or clones, of the pioneer female and so can reproduce without mating. This results in a rate of reproduction that is at least twice as high as that of the bisexual colony, which is composed roughly of 50 percent males.



Plant succession is at a stage where ideal conditions have been largely eliminated; the area has reverted to the habitat from which the lizards emigrated. Succession has resulted in less cover, sunlight, and insects. Carrying capacity has diminished until the population is at the low density of the forest situation.



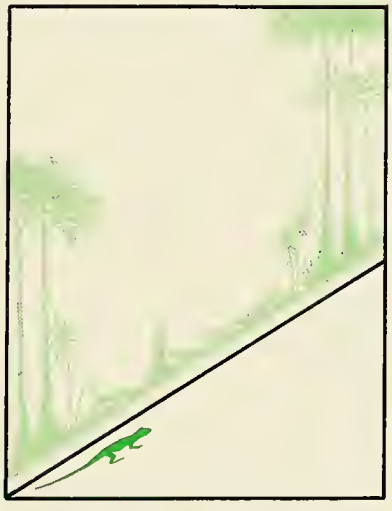
As constantly happens in a forest, another blowdown of trees has occurred. A similar, longer-lasting situation would be present where man has cleared part of a forest, creating an edge habitat. Again, at least two bisexual lizards of opposite sex must wander into the location to take advantage of it and produce a colony.



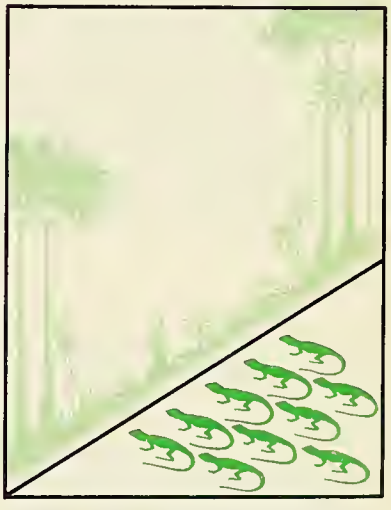
The situation may best be viewed as a fluid mosaic in which this species has high and low densities of both bisexual and unisexual populations. High-quality habitat appears unpredictably at sometimes widely scattered locations. Bisexual reproduction can be an effective means of colonizing such habitat, but it is not efficient.



The same factors work against the all-female colony, and the rate of population reduction is similarly governed by plant succession. The lesser genetic variability of these lizards may be disadvantageous at some point, although hybridization, producing triploid offspring, or random mutations could occur.



Because all-female colonies, in various optimal microhabitats scattered throughout the forest and its edges, may have larger populations, more unisexual individuals could be available to disperse from a given point. Even a juvenile parthenogenetic female can successfully start a colony soon after she matures.

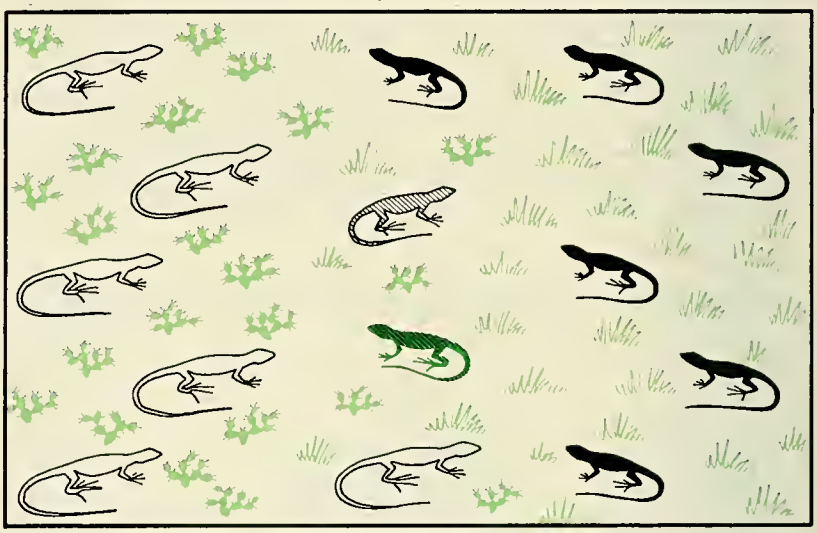


Parthenogenetic reproduction seems to have evolved because it permits rapid colonization of good, but transitory, habitats in species whose range contains considerable marginal habitat. Over a long period of time, the parthenogenetic females of a species could become extinct or the species could end up completely female.

Parthenogenetic reproduction has also become established in lizards through hybridization, resulting in all-female species. This is a type of sympatric speciation.



The western whiptail (white) is a desert-dwelling species and the little striped whiptail lizard (black) inhabits grassland in the American Southwest. Parts of their ranges come into proximity or overlap in a desert-grassland ecotone. Individuals from both species disperse into this buffer strip between the two primary populations, where they can exploit the available resources.



Mating between the two species has taken place. As would be expected from such a pairing, the offspring, of either sex (cross-hatched), is sterile. In this situation, however, a hybrid female carrying the trait for parthenogenetic reproduction (green) has appeared from a mating. Both types of hybrids are capable of exploiting the resources of the ecotone, but only parthenogenetic females can reproduce.



The parthenogenetic lizard has reproduced and become self-perpetuating. The all-female colony of hybrids has its own distinct traits, which are a combination of characteristics inherited from the western and little striped whiptails. This new species, the New Mexico whiptail (green), is a successful competitor within the "hybrid habitat," and can disperse into other habitats.

of males and females in about a one-to-one ratio. In some places, however, only females have been found. Biologist Robert L. Bezy has speculated that the all-female lizards evolved from bisexual populations because of specific ecological factors. Their apparently narrow requirements for temperature, humidity, the cover of logs and stumps, and insect prey associated with rotting wood would account for the overall rarity of this species. Under certain optimal conditions, however, these lizards can form relatively large local colonies.

Optimal conditions related to general topography and climate are relatively stable; those related to forest conditions and the occurrence of suitable logs are ever changing due to ecological succession. One fallen tropical tree can support a colony of *Lepidophyma,* and a number of dead trees can support a veritable population explosion of these lizards. But to take advantage of such ecological "windfalls" as the food and cover provided by decaying logs, the lizards must reach the logs in time and reproduce quickly. This is a precarious existence. The populations thriving in a disturbed area are, in a sense, doomed because ecological succession will result in decomposition of the logs and the growth of new trees. The lizards, which are really nominal forest dwellers, will become less successful as succession proceeds.

What seems to be at work is that in this species natural selection favors the evolution of efficient mechanisms for dispersing and colonizing localities that have been recently disturbed. Parthenogenesis is one such mechanism, and probably evolved through one or more females who carried a mutation or gene combination that allowed reproduction without males. Such females would be highly successful in establishing new colonies because a new population could be produced from the chance dispersal of only one parthenogenetic lizard into a previously unoccupied locality. Colonization of new areas is less efficient in bisexual species because a minimum of two compatible individuals of opposite sexes or a gravid female carrying offspring of both sexes would be required to establish another population.

The New Mexico whiptail lizard has all-female populations at all localities where it has been found. Biologists Charles H. Lowe and John W. Wright suggested that it originated as a hybrid between two bisexual species, the western whiptail, which lives primarily in deserts, and the little striped whiptail, which is a grassland species. Hybridization between the desert and grassland lizards probably occurred in the desert-grassland ecotone (transition zone), one of the habitats now occupied by the New Mexico species. The New Mexico whiptail displays many characteristics that are intermediate between the western and little striped whiptails. The thought follows that the hybrid offspring were ecologically successful in the "hybrid habitat" (the ecotone) as a consequence of having a set of genes from each of two different parental species well adapted to the habitats spanned by the ecotone.

As is often the case with hybrids, however, both the male and female offspring were probably sterile because of their inability to produce sex cells with balanced sets of genes. Of course, an organism is headed for extinction if it cannot reproduce, even if it is highly fit as an ecological competitor in a specific habitat. If, however, one or a few hybrid females were parthenogenetic, they would have been able to reproduce. After the original male and female sterile hybrids died, only the parthenogenetic females continued to perpetuate their kind. Once the species was established, its populations could move to accommodate shifts in the distribution of its habitat and, as in *Lepidophyma,* individual females could disperse and establish new colonies elsewhere.

Examples such as these have led scientists to suspect that parthenogenesis became established among reptiles in at least two different ways. For species in which hybridization was involved, the selective advantages are in allowing the offspring to produce eggs having complete sets of genes and in maintaining the gene combinations that are well suited for continued existence in specific habitats. In nonhybrid situations, the advantage of parthenogenesis is that it allows efficient colonization of new localities but not necessarily different habitats. Establishment of parthenogenetic reproduction appears to be in progress today in some species in which only females occur at some localities and both sexes are found at others.

When a nonhybrid mode of evolution was involved, the surviving parthenogenetic populations usually are considered to be of the same species as the bisexual popu-

Courtesy of Charles H. Lowe



Charles J. Cole



In 1902, Huerfano Butte, Arizona, was surrounded by grassland (top). This habitat supported the triploid unisexual Sonora whiptail lizard. By 1969, the habitat had changed to desert-grassland (bottom), and the diploid bisexual western whiptail was the predominant species. Some interbreeding has occurred, producing tetraploid hybrids.

lations from which they evolved, since the only basic differences are in the mode of reproduction. Populations in which parthenogenesis evolved through hybridization are considered to be new species because usually the lizards are clearly different from both parental species in anatomy, habitats, and biochemical characteristics, and in addition, they regularly perpetuate their own distinct kind.

The mode of egg production in parthenogenetic reptiles appears to be one in which all offspring from one female are essentially carbon copies. Except for random gene mutations, each lineage is, in essence, a clone. Thus, once a lizard becomes parthenogenetic and has a combination of genes that allows it to be a successful competitor in certain ecological situations, the genetic inheritance is well preserved, generation after generation, with less genetic variation than occurs in bisexual species. This may mean that, in the long run, parthenogenetic species are at an evolutionary disadvantage because of reduced variability and evolutionary plasticity for responding to changing environments.

There are ways in which gene combinations might suddenly change in parthenogenetic lizards. For example, a female of a diploid parthenogenetic species could mate with a male of a closely related species. Since the parthenogenetic female produces eggs that contain two full sets of chromosomes and genes and the male's spermatozoa carry another set, the hybrid offspring, if viable, would be triploids —that is, they would contain three complete sets of chromosomes and genes in each typical body cell. In fact, several all-female species of lizards consist only of triploid individuals, which produce triploid offspring similar to themselves. These species probably evolved through hybridization between unisexual and bisexual lizards.

Going a step further, there is the possibility of a triploid parthenogenetic female mating with a male of another species. In this case, the hybrid offspring would be tetraploids—with three sets of chromosomes and genes inherited from the mother and one set from the father. Two hybrids of this sort have been found in southern Arizona, at Huerfano Butte, south of Tucson. The female parent was probably a Sonora whiptail lizard, and the male parent a western whiptail. Photographs of the locality taken about the turn of the century document that it used to be grassland. By 1969, when the tetraploid hybrids were discovered, the habitat had changed dramatically to desert-grassland; desertification having occurred coincidentally with a drop in the water table, and other changes, in southern Arizona. Biologists think that the triploid all-female Sonora whiptail abounded in the area when the habitat was a more suitable, cooler, moister grassland, and that the diploid, bisexual western whiptail recently invaded the area as its habitat, the desert, expanded. Today, the desert species is plentiful throughout the area and the parthenogenetic species clings to a local remnant of grassland where the tetraploid hybrids occasionally arise. Given the appropriate combination of events, perhaps such hybrids could evolve into a tetraploid species.

As mentioned earlier, lizard eggs that develop without hybridization or fertilization normally produce essentially identical female offspring. However, hybrids that develop from fertilized eggs of parthenogenetic females exhibit males. The sex of a hybrid depends on whether the sperm from the male was carrying the X or Y chromosome. So when a parthenogenetic female mates with a male of a different species, she can produce a variety of offspring in one clutch of eggs: some can be females identical to the mother (from eggs that were not fertilized); others can be polyploid hybrids bearing differences in various traits; and the hybrids can be either female or male.

When the first substantial reports indicated that some lizards reproduce without males, little was it known that parthenogenetic reproduction is only one of several ways in which these reptiles are nonconformists in vertebrate biology. The discovery of normal triploidy among reptiles was also a surprise to many biologists. So, too, was the discovery that the evolution of some species involved hybridization between two previously existing species, which is sympatric speciation—not involving geographic isolation of a population of a previously existing species. Such hybridization occurred in part because ecological disruptions created newly disturbed habitats in which two geographically adjacent species could come into contact and interbreed. The disturbed habitats were most suitable to the resultant hybrids, which survived as all-female species once they developed parthenogenetic reproduction. This negated the typical problem of sterility and provided rapid fixation of a hybrid combination of genes that was suitable to the disturbed habitat.

Disturbed or fluctuating habitats also played a critical role for lizards in which parthenogenesis evolved without hybridization. In these cases, the original bisexual species was adapted to forest edge situations (ecotones) or areas containing logs and pioneer vegetation. As plant succession proceeded, the local habitat changed and became less suitable to the lizards. In such species, parthenogenetic reproduction improved the efficiency of colony formation after new disturbances created suitable habitat.

In both cases, the evolution of parthenogenetic reproduction allows rapid colonization of disturbed habitats, a critical ability for terrestrial animals whose optimal habitat is transitory and/or whose range contains considerable marginal habitat. □

The western whiptail (top) and the little striped whiptail (middle) have mated in the wild and produced a new species of all-female lizards, the New Mexico whiptail (bottom). The parthenogenetic hybrids have colonized riparian habitat along the Rio Grande system, in addition to desert-grassland ecotones.



Of Cricket Song and Sex

Male field crickets attract females with their song, but they also draw aggressive competitors, hungry predators, and dangerous parasites

by William Cade

In most parts of the world, the rhythmic songs of crickets fill the air on warm nights. These peaceful-sounding love songs of male crickets not only attract females; they are also battle cries. Competing males fight violently for females, other males silently "steal" females attracted by a neighboring male's song, and some predators and parasites locate males by their conspicuous calling songs. Song is the most obvious aspect of a cricket's complicated sexual behavior.

Male crickets produce song by rapidly rubbing their wings together. The hardened wings have special surfaces for producing sound. Of the more than 2,000 cricket species that have been described, each has a very specific calling song, once thought to have evolved principally to prevent matings between members of different species. However, males of the same species also compete by means of song for sexually receptive females.

For a male animal, the purpose of any type of reproductive competition is that he should mate as many times as possible. Reproductive success, or more precisely the propagation of an individual animal's genes, is usually considered to be behind competitive behavior. Until recently, animal behavior was often analyzed as an adaptation





Because this tree cricket nymph is too young to have wings, it cannot produce song. It is lighter and softer bodied than field crickets, which live in burrows.

Joseph C. Scipio

Edward S. Ross





Edward S. Ross

Edward S. Ross



Almost identical to Gryllus integer, *these field crickets are lighter in color and inhabit domestic dwellings rather than fields and lawns. At left, a quiescent male; at right, a male whose vibrating wings are producing song. Bottom left, a female, which cannot fly. Her short wings leave her abdominal segments exposed. Each cricket species has its own calling song to attract mates of the same species. Some* Gryllus integer *males call; others remain silent, attracting fewer predators.*

benefiting survival of the species. Behavior also perpetuates an individual's genetic line and can simultaneously benefit and hinder an individual's ability to reproduce. This important concept helps explain reproductive competition in crickets.

In sexual behavior, male field crickets are very aggressive toward other males, biting with powerful mandibles and intermittently producing loud bursts of song. Some males routinely defeat others in fights, ascending to the top of their own hierarchy. Dominant males call for females from specific sites. They defend these territories against other males, searching out and attacking those who are trying to mate. By aggressively securing a calling site and interfering with other males, a dominant male cricket has access to more females and therefore leaves more offspring.

Because fighting may result in injuries severe enough to prevent future mating, an individual cricket's behavior can be expected to reflect a combination of costs and benefits. If two unevenly matched males are contending for a nearby female, the weaker male may benefit most from avoiding a fight, remaining uninjured and, therefore, capable of more matings in the future.

When I decided to study patterns of male cricket competition for females, I chose the field cricket *Gryllus integer*, a species that commonly occurs in grassy fields and residential lawns in central Texas and throughout the Southwest. During my early observations, which took place at night in both the field and in a specially constructed outdoor arena, I noticed that while some males called regularly, other, silent males walked or remained stationary, often very close to a calling male. In a sense, silent males behaved like satellites of the calling male. Katydids and grasshoppers, close relatives of crickets, also demonstrate this system of callers and satellites. In these species, calling and satellite behavior are alternative ways in which males acquire mates. Some males call and attract females; meanwhile, others silently intercept females attracted by the calling.

Alternative patterns of mating in the same species are probably widespread. They have certainly been observed in cockroaches, mud wasps, bees, lightning bugs, fishes, frogs, lizards, and birds. But this behavior presents something of a problem for evolutionary biologists. If, in an animal population, one behavior attracts mates more successfully than alternatives, the most successful behavior should eventually become the population's predominant form of mating. Under what circumstances, then, do alternative mating behaviors occur in the same population of males?

Seeking an answer, I attempted to identify some of the costs and benefits associated with the behavior of calling field crickets and that of their satellites. For a male cricket, the obvious benefit of calling is that it attracts females for mating, and I have observed *Gryllus integer* females walking, sometimes running, directly to a calling male and mating with him. But a possible cost of calling is that the male also attracts predators. Using tape-recorded cricket song, I tested the ability of various animals to locate crickets by sound. For the most part, tests with birds, frogs, toads, and some invertebrates were unsuccessful. But one night in August 1974, when I was beginning to doubt that predators were able to locate calling cricket males, I noticed a red-eyed yellow fly (*Euphasiopteryx ochracea*) standing motionless on a loudspeaker that was broadcasting cricket song.

Since that night, I have used taped cricket song to attract many of these flies, which are parasites of crickets and katydids, but I have found that only the females are attracted. All the females contained





A male tree cricket's song has attracted a female. As these unaggressive crickets mate, the female (over the male) feeds on juices exuded from the male's wing bases.

Edward S. Ross

Stephen Dalton, Photo Researchers



many living young, or larvae, in their reproductive tubules. Responding to a calling song, female flies deposit their larvae on a male cricket. The larvae burrow inside the cricket, feed and grow for about a week, then emerge and pupate.

Fly parasitism always kills the host cricket, which dies as the larvae emerge. Flies also deposit larvae in a male cricket's territory. Larvae stand erect and readily stick to crickets walking nearby. Because field crickets are often hidden by dense vegetation or burrows in the ground, larvae deposited near the source of cricket song may parasitize hidden calling males and perhaps satellites. However, in the field, female crickets did not draw flies, calling males were usually parasitized, and noncalling males rarely contained fly larvae. *Euphasiopteryx ochracea* specializes in calling male crickets.

Fly parasitism is a major danger to calling male crickets, but males' reactions to each other also influence sexual behavior. When calling, *Gryllus integer* males space themselves at regular intervals in a field. Although I have observed fights between calling males, their spacing may also be due to threats of aggression communicated by calling song. I tested this possibility by broadcasting a previously recorded calling song to a calling male. When I gradually moved the loudspeaker closer, up to an average distance of two feet, some males stopped calling, immediately ran to the loudspeaker, and viciously attacked another male I had tethered nearby. In the field, calling neighbors are always at least three feet apart, and I found that at this distance, experimentally produced aggressive



A female dark bush cricket devours a fly. Female field crickets do not seem to attract parasitic flies. Fly larvae deposited in field cricket habitats parasitize males.

behavior was unlikely. Calling neighbors probably separate to avoid the costs of fighting. Conversely, if a male prevents other males from calling nearby, he benefits by gaining a monopoly on females, or at least the ability to attract females, in the immediate vicinity.

Many calling males did not behave aggressively when I played taped song in their direction. These males stopped calling and remained stationary or walked in the area as if they were satellites of the loudspeaker. Males began to behave like satellites at an average distance from the loudspeaker of five feet, much greater than the distance at which caller males became aggressive. Apparently, the threat of aggression from a competing male (or what sounds like a competing male) causes some males that were previously callers to behave like satellites. In completely natural circumstances, a satellite male may benefit by avoiding both parasitic flies and aggression from calling males. Satellites walk very close to calling males without risking attacks and are therefore in a better position to intercept approaching females.

In another type of sexual aggression, some silent *Gryllus integer* males run up to calling males and attack them. Both combatants bite, push, and make short, loud bursts of song. The behavior of these silent aggressive males, very different from that of satellites, may be a way of securing a calling site by displacing a previous resident. Possession of a signaling site greatly enhances a male cricket's ability to fight. Alternatively, a silent male's aggression may prevent other males from calling, leaving more females for the attacker. At any rate, attacks by previously silent males represent another cost to a male that calls for females.

If a male starts calling to attract females, he runs the risk of attracting aggressive silent males, parasitic flies, and even the cat next door (cats have been shown to be attracted to cricket and katydid song). Given these sizable dangers, why do males call? Probably because calling generally results in more matings per night. Satellites often tried to mate by following females and producing courting song —a soft sound, almost inaudible to human ears, that stimulates nearby females prior to mating. However, very few matings resulted from satellite males' courtship. Male sexual behavior evidently involves certain compromises: satellites avoid flies, but at the expense of success with females; calling males mate often, but risk parasitic flies and aggressive males.

One obvious variation in calling told me more about the relative mating success resulting from different male behaviors. Male callings range from louder than ninety decibels to lower than forty. In the field, when I simultaneously played

taped calling song at different volumes, females, aggressive male crickets, and parasitic flies were attracted much more often to the louder song. Loud callers probably draw many females, but they also attract many aggressive males and flies. Softly calling males attract fewer females, but fewer flies and male attackers are drawn to them.

Cricket males, like the males of most animal species, compete for choosy females. Male and female sexual behaviors theoretically differ because of the relative amounts of metabolic energy invested in the sex cells. Because females invest heavily in eggs, or potential offspring, they need to choose the best fertilizing mate. Males, by virtue of their small investment in sperm, are less discriminating.

Female crickets apparently prefer to mate with calling males, perhaps because calling identifies a male as being of the same species, a very important mate criterion. Calling might also signal that a male has a suitable genotype. Female preference for calling males partially accounts for more calling behavior at particular times of night. Slowly bicycling through a thirty-block residential area at all hours of the night, I listened for, and counted, calling crickets. Two hours before sunrise I noticed a shift: some previously silent males now began to call. Although many males remained silent, by sunrise the number of callers had increased threefold, then rapidly declined.

To find out whether increased calling corresponds to an increase in female attraction, I played taped songs and counted the females collected in a trap mounted on the loudspeaker. I was surprised to find that female attraction actually decreases during the hours that calling behavior increases, so that no females are attracted at sunrise. Most males might be expected to call at times when females are readily attracted to their songs and not when females are least likely to come. Parasitic flies are attracted to taped song well into the daylight hours, so an absence of fly attacks is not a reason why some previously silent males begin to call. At dawn, however, males tend to call at relatively low volume, and therefore probably attract few flies. Still, why should a male call, even at low volume, if females are not attracted?

Early in the night, male and female crickets openly walk and feed in a given area. But at sunrise, females and both calling and noncalling males gather in small groups under dense vegetation to avoid waking birds that, while not attracted to cricket song, would certainly prey on wandering crickets. Female crickets in these small hidden groups are still sexually receptive and matings do occur. At sunrise, aggressive males are not attracted to calling males, and the cost of singing is temporarily reduced. Having been unsuccessful at mating the previous night, some previously silent males begin to call at low volume as a last attempt to mate with nearby females.

In a field cricket population, alternative male mating behaviors are maintained by balancing mating success and longevity. On a given night, a calling male cricket will mate successfully. But the insect's life could be shortened by the flies and aggressive males it attracts. During any one night, satellite behavior could attract few mates, but by extending a male's life expectancy, it would guarantee future mating opportunities. In drawing conclusions about sexual behavior, many variables have to be considered: some males shift from calling to satellite behavior or adopt intermediate patterns, and the costs and benefits of mating behavior may change greatly during the course of of a night. However, over a male cricket's lifetime, calling and satellite behavior may result in roughly equal numbers of matings. If they do, both behaviors are equally successful and will be maintained in the population. □



Common throughout the northeastern United States, the male snowy tree cricket sings in a high-pitched trill. Like all crickets, it produces song by rapidly rubbing its wings together.

Alvin E. Staffan, Photo Researchers





Rituals at McDonald's

by Conrad P. Kottak

The success of this fast-food chain may be based, not so much on the taste of a Big Mac, as on the security offered in ordering one

The world is blessed each day, on the average, with the opening of a new McDonald's restaurant. They now number more than 4,000 and dot not only the United States but also such countries as Mexico, Japan, Australia, England, France, Germany, and Sweden. The expansion of this international web of franchises and company-owned outlets has been fast and efficient; a little more than twenty years ago McDonald's was limited to a single restaurant in San Bernardino, California. Now, the number of McDonald's outlets has far outstripped the total number of fast-food chains operative in the United States thirty years ago.

McDonald's sales reached $1.3 billion in 1972, propelling it past Kentucky Fried Chicken as the world's largest fast-food chain. It has kept this position ever since. Annual sales now exceed $3 billion. McDonald's is the nation's leading buyer of processed potatoes and fish. Three hundred thousand cattle die each year as McDonald's customers down another three billion burgers. A 1974 advertising budget of $60 million easily made the chain one of the country's top advertisers. Ronald McDonald, our best-known purveyor of hamburgers, French fries, and milkshakes, rivals Santa Claus and Mickey Mouse as our children's most familiar fantasy character.

How does an anthropologist, accustomed to explaining the life styles of diverse cultures, interpret these peculiar developments and attractions that influence the daily life of so many Americans? Have factors other than low cost, taste, fast service, and cleanliness —all of which are approximated by other chains—contributed to McDonald's success? Could it be that in consuming McDonald's products and propaganda, Americans are not just eating and watching television but are experiencing something comparable in some respects to a religious ritual? A brief consideration of the nature of ritual may answer the latter question.

Several key features distinguish ritual from other behavior, according to anthropologist Roy Rappaport. Foremost, are formal ritual events—stylized, repetitive, and stereotyped. They occur in special places, at regular times, and include liturgical orders—set sequences of words and actions laid down by someone other than the current performer.

Rituals also convey information about participants and their cultural traditions. Performed year after year, generation after generation, they translate enduring messages, values, and sentiments into observable action. Although some participants may be more strongly committed than others to the beliefs on which rituals are based, all people who take part in joint public acts signal their acceptance of an order that transcends their status as individuals.

In the view of some anthropologists, including Rappaport himself, such secular institutions as McDonald's are not comparable to rituals. They argue that rituals involve special emotions, nonutilitarian intentions, and supernatural entities that are not characteristic of Americans' participation in McDonald's. But other anthropologists define ritual more broadly. Writing about football in contemporary America, William Arens (*see* "The Great American Football Ritual," *Natural History*, October 1975) points out that behavior can simultaneously have sacred as well as secular aspects. Thus, on one level, football can be interpreted simply as a sport, while on another, it can be viewed as a public ritual.

While McDonald's is definitely a mundane, secular institution—just a place to eat—it also assumes some of the attributes of a sacred place. And in the context of comparative religion, why should this be surprising? The French sociologist Emile Durkheim long ago pointed out that some societies worship the ridiculous as well as the sublime. The distinction between the two does not depend on the intrinsic qualities of the sacred symbol. Durkheim found that Australian aborigines often worshiped such humble and nonimposing creatures as ducks, frogs, rabbits, and grubs—animals whose inherent qualities hardly could have been the origin of the religious sentiment they inspired. If frogs and grubs can be elevated to a sacred level, why not McDonald's?

I frequently eat lunch—and, occasionally, breakfast and dinner—at McDonald's. More than a year ago, I began to notice (and have subsequently observed more carefully) certain ritual behavior at these fast-food restaurants. Although for natives, McDonald's seems to be just a place to eat, careful observation of what goes on in any outlet in this country reveals an astonishing degree of formality and behavioral uniformity on the part of both staff and customers. Particularly impressive is the relative invariance in act and utterance that has developed in the absence of a distinct theological doctrine. Rather, the ritual aspect of McDonald's rests on twentieth-century technology—particularly

Richard Tomlinson



automobiles, television, work locales, and the one-hour lunch.

The changes in technology and work organization that have contributed to the chain's growth in the United States are now taking place in other countries. Only in a country such as France, which has an established and culturally enshrined cuisine that hamburgers and fish fillets cannot hope to displace, is McDonald's expansion likely to be retarded. Why has McDonald's been so much more successful than other businesses, than the United States Army, and even than many religious institutions in producing behavioral invariance?

Remarkably, even Americans traveling abroad in countries noted



Black-and-white photographs by Mark Haven

for their distinctive food usually visit the local McDonald's outlet. This odd behavior is probably caused by the same factors that urge us to make yet another trip to a McDonald's here. Wherever a McDonald's may be located, it is a home away from home. At any outlet, Americans know how to behave, what to expect, what they will eat, and what they will pay. If one has been unfortunate enough to have partaken of the often indigestible pap dished out by any turnpike restaurant monopoly, the sight of a pair of McDonald's golden arches may justify a detour off the highway, even if the penalty is an extra toll.

In Paris, where the French have not been especially renowned for making tourists feel at home, McDonald's offers sanctuary. It is, after all, an American institution, where only Americans, who are programmed by years of prior experience to salivate at the sight of the glorious hamburger, can feel completely at home. Americans in Paris can temporarily reverse roles with their hosts; if they cannot act like the French, neither can the French be expected to act in a culturally appropriate manner at McDonald's. Away from home, McDonald's, like a familiar church, offers not just hamburgers but comfort, security, and reassurance.



An American's devotion to McDonald's rests in part on uniformities associated with almost all McDonald's: setting, architecture, food, ambience, acts, and utterances. The golden arches, for example, serve as a familiar and almost universal landmark, absent only in those areas where zoning laws prohibit garish signs. At a McDonald's near the University of Michigan campus in Ann Arbor, a small, decorous sign—golden arches encircled in wrought iron—identifies the establishment. Despite the absence of the towering arches, this McDonald's, where I have conducted much of my fieldwork, does not suffer as a ritual setting. The restaurant, a contemporary brick structure that has been nominated for a prize in architectural design, is best known for its stained-glass windows, which incorporate golden arches as their focal point. On bright days, sunlight floods in on waiting customers through a skylight that recalls the clerestory of a Gothic cathedral. In the case of this McDonald's, the effect is to equate traditional religious symbols and golden arches. And in the view of the natives I have interviewed, the message is clear.

When Americans go to a McDonald's restaurant, they perform an ordinary, secular, biological act—they eat, usually lunch. Yet, immediately upon entering, we can tell from our surroundings that we are in a sequestered place, somehow apart from the messiness of the world outside. Except for such anomalies as the Ann Arbor campus outlet, the town house McDonald's in New York City, and the special theme McDonald's of such cities as San Francisco, Saint Paul, and Dallas, the restaurants rely on their arches, dull brown brick, plate-glass sides, and mansard roofs to create a setting as familiar as home. In some of the larger outlets, murals depicting "McDonaldland" fantasy characters, sports, outdoor activities, and landscapes surround plastic seats and tables. In this familiar setting, we do not have to consider the experience. We know what we will see, say, eat, and pay.

Behind the counter, McDonald's employees are differentiated into such categories as male staff, female staff, and managers. While costumes vary slightly from outlet to outlet and region to region, such apparel as McDonald's hats, ties, and shirts, along with dark pants and shining black shoes, are standard.

The food is also standard, again with only minor regional variations. (Some restaurants are selected to test such new menu items as "McChicken" or different milkshake flavors.) Most menus, however, from the rolling hills of Georgia to the snowy plains of Minnesota, offer the same items. The prices are also the same and the menu is usually located in the same place in every restaurant.

Utterances across each spotless counter are standardized. Not only are customers limited in what they can choose but also in what they can say. Each item on the menu has its appropriate McDonald's designation: "quarter pounder with cheese" or "filet-O-fish" or "large fries." The customer who asks, "What's a Big Mac?" is as out of place as a southern Baptist at a Roman Catholic Mass.

At the McDonald's that I frequent, the phrases uttered by the salespeople are just as standard as those of the customers. If I ask for a quarter pounder, the ritual response is "Will that be with cheese, sir?" If I do not order French fries, the agent automatically incants, "Will there be any fries today, sir?" And when I pick


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HASH BROWNS
TEA
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up my order, the agent conventionally says, "Have a nice day, sir," followed by, "Come in again."

Nonverbal behavior of McDonald's agents is also programmed. Prior to opening the spigot of the drink machine, they fill paper cups with ice exactly to the bottom of the golden arches that decorate them. As customers request food, agents look back to see if the desired item is available. If not, they reply, "That'll be a few minutes, sir (or ma'am)," after which the order of the next customer is taken.

McDonald's lore of appropriate verbal and nonverbal behavior is even taught at a "seminary," Hamburger University, located in Elk Grove Village, Illinois, near Chicago's O'Hare airport. Managers who attend choose either a two-week basic "operator's course" or an eleven-day "advanced operator's course." With a 360-page *Operations Manual* as their bible, students learn about food, equipment, and management techniques—delving into such esoteric subjects as buns, shortening, and carbonization. Filled with the spirit of McDonald's, graduates take home such degrees as bachelor or master of hamburgerology to display in their outlets. Their job is to spread the word—the secret success formula they have learned—among assistant managers and crew in their restaurants.

The total McDonald's ambience invites comparison with sacred places. The chain stresses clean living and reaffirms those traditional American values that transcend McDonald's itself. Max Boas and Steve Chain, biographers of McDonald's board chairman, Ray Kroc, report that after the hundredth McDonald's opened in 1959, Kroc leased a plane to survey likely sites for the chain's expansion. McDonald's would invade the suburbs by locating its outlets near traffic intersections, shopping centers, and churches. Steeples figured prominently in Kroc's plan. He believed that suburban churchgoers would be preprogrammed consumers of the McDonald's formula—quality, service, and cleanliness.

McDonald's restaurants, nestled





beneath their transcendent arches and the American flag, would enclose immaculate restrooms and floors, counters and stainless steel kitchens. Agents would sparkle, radiating health and warmth. Although to a lesser extent than a decade ago, management scrutinizes employees' hair length, height, nails, teeth, and complexions. Long hair, bad breath, stained teeth, and pimples are anathema. Food containers also defy pollution; they are used only once. (In New York City, the fast-food chain Chock Full O' Nuts foreshadowed this theme long ago and took it one step further by assuring customers that their food was never touched by human hands.)

Like participation in rituals, there are times when eating at McDonald's is not appropriate. A meal at McDonald's is usually confined to ordinary, everyday life. Although the restaurants are open virtually every day of the year, most Americans do not go there on Thanksgiving, Easter, Passover, or other religious and quasi-religious days. Our culture reserves holidays for family and friends. Although Americans neglect McDonald's on holidays, the chain reminds us through television that it still endures, that it will welcome us back once our holiday is over.

The television presence of McDonald's is particularly obvious on holidays, whether it be through the McDonald's All-American Marching Band (two clean-cut high school students from each state) in a nationally televised Thanksgiving Day parade or through sponsorship of sports and family entertainment programs.

Although such chains as Burger King, Burger Chef, and Arby's compete with McDonald's for the fast-food business, none rivals McDonald's success. The explanation reflects not just quality, service, cleanliness, and value but, more importantly, McDonald's advertising, which skillfully appeals to different audiences. Saturday morning television, for example, includes a steady dose of cartoons and other children's shows sponsored by McDonald's. The commercials feature several McDonaldland fantasy characters, headed by the clown Ronald McDonald, and often stress the enduring aspects of McDonald's. In one, Ronald has a time machine that enables him to introduce hamburgers to the remote past and the distant future. Anyone who noticed the shot of the McDonald's restaurant in the Woody Allen film *Sleeper,* which takes place 200 years hence, will be aware that the message of McDonald's as eternal has gotten across. Other children's commercials gently portray the conflict between good (Ronald) and evil (Hamburglar). McDonaldland's bloblike Grimace is hooked on milkshakes, and Hamburglar's addiction to simple burgers regularly culminates in his confinement to a "patty wagon," as Ronald and Big Mac restore and preserve the social order.

Pictures of McDonaldland appear on cookie boxes and, from time to time, on durable plastic cups that are given away with the purchase of a large soft drink. According to Boas and Chain, a McDonaldland amusement park, comparable in scale to Disneyland, is planned for Las Vegas. Even more obvious are children's chances to meet Ronald McDonald and other McDonaldland characters in the flesh. Actors portraying Ronald scatter their visits, usually on Saturdays, among McDonald's outlets throughout the country. A Ronald can even be rented for a birthday



party or for Halloween trick or treating.

McDonald's adult advertising has a different, but equally effective, theme. In 1976, a fresh-faced, sincere young woman invited the viewer to try breakfast—a new meal at McDonald's—in a familiar setting. In still other commercials, healthy, clean-living Americans gambol on ski slopes or in mountain pastures. The single theme running throughout all the adult commercials is personalism. McDonald's, the commercials tell us, is not just a fast-food restaurant. It is a warm, friendly place where you will be graciously welcomed. Here, you will feel at home with your family, and your children will not get into trouble. The word *you* is emphasized—"You deserve a break today"; "You, you're the one"; "We do it all for you." McDonald's commercials say that you are not simply a face in a crowd. At McDonald's, you can find respite from a hectic and impersonal society—the break you deserve.

Early in 1977, after a brief flirtation with commercials that harped on the financial and gustatory benefits of eating at McDonald's, the chain introduced one of its most curious incentives—the "Big Mac attack." Like other extraordinary and irresistible food cravings, which people in many cultures attribute to demons or other spirits, a Big Mac attack could strike anyone at any time. In one commercial, passengers on a jet forced the pilot to land at the nearest McDonald's. In others, a Big Mac attack had the power to give life to an inanimate object, such as a suit of armor, or restore a mummy to life.

McDonald's advertising typically de-emphasizes the fact that the chain is, after all, a profit-making organization. By stressing its program of community projects, some commercials present McDonald's as a charitable organization. During the Bicentennial year, commercials reported that McDonald's was giving 1,776 trees to every state in the union. Brochures at outlets echo the television mes-

sage that, through McDonald's, one can sponsor a carnival to aid victims of muscular dystrophy. In 1976 and 1977 McDonald's managers in Ann Arbor persuaded police officers armed with metal detectors to station themselves at restaurants during Halloween to check candy and fruit for hidden pins and razor blades. Free coffee was offered to parents. In 1976, McDonald's sponsored a radio series documenting the contributions Blacks have made to American history.

McDonald's also sponsored such family television entertainment as the film *The Sound of Music*, complete with a prefatory, sermonlike address by Ray Kroc. Commercials during the film showed Ronald McDonald picking up after litterbugs and continued with the theme, "We do it all for you." Other commercials told us that McDonald's supports and works to maintain the values of American family life—and went so far as to suggest a means of strengthening what most Americans conceive to be the weakest link in the nuclear family, that of father–child. "Take a father to lunch," kids were told.

Participation in McDonald's rituals involves temporary subordination of individual differences in a social and cultural collectivity. By eating at McDonald's, not only do we communicate that we are hungry, enjoy hamburgers, and have inexpensive tastes but also that we are willing to adhere to a value system and a series of behaviors dictated by an exterior entity. In a land of tremendous ethnic, social, economic, and religious diversity, we proclaim that we share something with millions of other Americans.



Sociologists, cultural anthropologists, and others have shown that social ties based on kinship, marriage, and community are growing weaker in the contemporary United States. Fewer and fewer people participate in traditional organized religions. By joining sects, cults, and therapy sessions, Americans seek many of the securities that formal religion gave to our ancestors. The increasing cultural, rather than just economic, significance of McDonald's, football, and similar institutions is intimately linked to these changes.

As industrial society shunts people around, church allegiance declines as a unifying moral force. Other institutions are also taking over the functions of formal religions. At the same time, traditionally organized religions—Protestantism, Catholicism, and Judaism—are reorganizing themselves along business lines. With such changes, the gap between the symbolic meaning of traditional religions and the realities of modern life widens. Because of this, some sociologists have argued that the study of modern religion must merge with the study of mass culture and mass communication.

In this context, McDonald's has become one of many new and powerful elements of American culture that provide common expectations, experience, and behavior—overriding region, class, formal religious affiliation, political sentiments, gender, age, ethnic group, sexual preference, and urban, suburban, or rural residence. By incorporating—wittingly or unwittingly—many of the ritual and symbolic aspects of religion, McDonald's has carved its own important niche in a changing society in which automobiles are ubiquitous and where television sets outnumber toilets. □


Happy Birthday

Climate and the Planets

by Richard Goody

Knowledge gained in the exploration of Mars and Venus throws light on questions concerning the terrestrial atmosphere

Can ideas gleaned from studies of the inner planets point the way to the solution of an important terrestrial problem? The question is obviously rhetorical since I anticipate that the reader will answer "yes." My personal research interests lie both in the behavior of the earth's atmosphere and in the nature of the other planets of the solar system. Although the planets differ greatly from one another, they also have important fundamental similarities. In so stating I am thinking mainly of the inner planets—Venus, Mars, and Earth. The outer planets, Jupiter, Saturn, Uranus, and Neptune, and the two small, airless bodies, Pluto and Mercury, differ sufficiently from the earth that analogies are few.

In my professional work I have found it interesting and instructive to let my thoughts go back and forth from the immense detail known about our own planet to the sparser and very different information available from Mars and Venus. I hope to give a general impression of what this implies by means of a few specific examples.

The terrestrial problem that I have in mind is climate and its variation, a topic that becomes increasingly important as the criticality of global food supplies receives more emphasis and as our capability of understanding our atmosphere increases. We are still in an early research phase. I doubt very much whether there will soon, if ever, be ten-year predictions of the climate or safe and controlled means of changing it. I emphasize the words "safe and controlled" because man, with characteristic haste, is already involved in both deliberate and accidental climate modification without the minimum understanding required to make such tampering safe and controlled. But that is not part of this story.

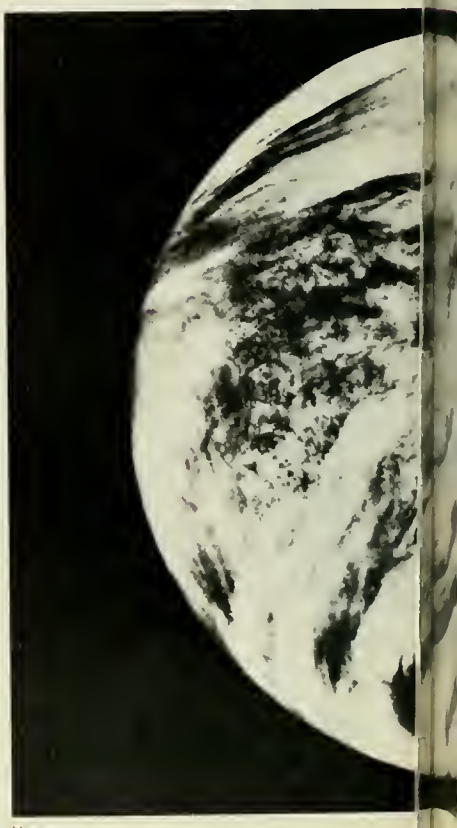
I can present a picture of climatic change in terms of recent and familiar human experiences, from the pages of written history, from the testimony of archeological finds, and from many aspects of the geologic record. In recent decades, particularly because of the power of isotopic-dating techniques, these sources of information have coalesced into the beginnings of a consistent picture of significant changes in all meteorological elements, on every time scale from year to year to tens of millions of years.

To look at recent events, a catastrophic drought in the Sahel region of North Africa is now, fortunately, receding; on the other hand, we are



Earth

NASA



Venus

experiencing difficulties and discomfort from a series of dry years in the western United States. Before that, in the 1960s, it was the turn of the east coast, which suffered a mini-drought that nearly emptied the reservoirs. And, to make the Great Depression even less bearable, western Kansas and other parts of the Great Plains suffered the dust bowl disasters of the 1930s. All of these events involved decreased rainfall, undoubtedly the most important aspect of climatic change, although temperature is easier to assess objectively.

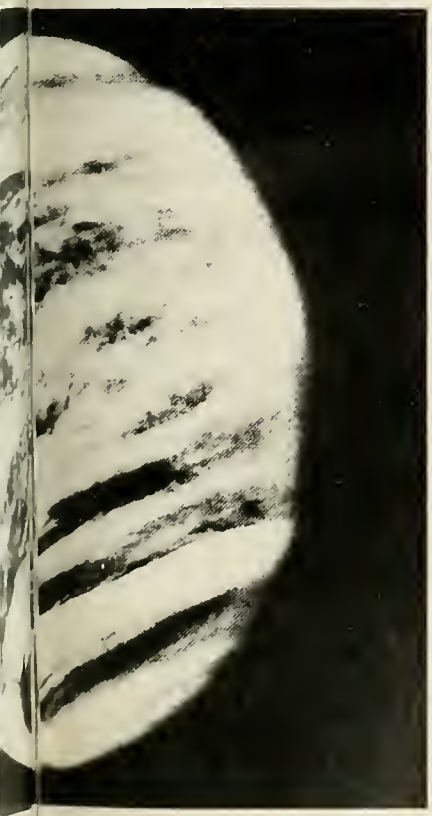
From about 1890, when the modern thermometer became available, until 1940, amateur scientists helped to establish that, at least in the Northern Hemisphere, the temperature rose about 0.6°C. You may regard that as a very small change but, maintained over many years, it can have important effects. I recollect climbing in Austria and Switzerland in the 1950s with maps based on surveys made in the early part of the century. The glaciers I encountered were not where they were shown on the maps; in some cases the snout was several miles farther back than indicated.

This warming up seems to have been part of a general trend leading out of a cold period in the sixteenth, seventeenth, and eighteenth centuries known as the Little Ice Age, a time when British writings refer to ice fairs on the Thames in London at which oxen were roasted on open fires. Needless to say, this would be inconceivable nowadays.

As we go backward from the present, the records become less precise; nonetheless they show that we are looking at a continuing series of climatic changes. The archeological records show major differences in human life patterns that can only be accounted for in terms of a changed environment. The Norse voyages to North America would have been difficult, and the colonization of Greenland impossible, with the present climate. Apparently, the North Atlantic had a mild climate from A.D. 600 to 1300.

During the same period there must have been important changes in the southwest of this country. Pueblo Bonito, in what is now New Mexico, exists only as a ruin in an inhospitable canyon where the descendants of the Anasazi can no longer live. Elaborate dwellings still

The inner planets, Earth, Venus, and Mars, have very different atmospheres. Nevertheless, information about our planetary neighbors gained from space probes can help us understand climatic change on Earth.



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retain roof timbers from trees that could not grow today in any accessible location. In the eleventh and twelfth centuries the Anasazi migrated to the Hopi mesas, in what is now Arizona, and to the Rio Grande, presumably because their water supplies failed.

Archeological and anthropological reasoning takes us further back, to times when the Sahara had adequate rainfall for agriculture and to intervals, some 10,000 to 20,000 years ago, when human beings could migrate from Asia to America across the Bering Strait. In that period we enter the most recent of the great Pleistocene ice surges, which, according to the geologic record, came and went periodically during the last million years. During one of these major ice surges, the temperature of the Northern Hemisphere may have been as little as 10°C colder than today. There is no reason to believe that a similar cooling could not happen again.

At this point you may reasonably wonder what Mars and Venus can have to do with the problem of climatic change. As I have already implied, the answer is relatively little, directly, but a great deal indirectly. Curiously enough, although we can now predict weather for a few days ahead, we are very uncertain as to the physical causes leading to the climate in any given epoch. Many important considerations may be involved. For one, the sun's radiation output may change, altering the total amount of heat falling on the earth. This heat provides the driving force for all atmospheric motions and is fundamental to all climate considerations. (Some aspects of solar variation have been described in "The Turbulent Sun," a supplement in *Natural History*, November 1976.) Other important possibilities are changes in the earth's surface caused by crustal plate motions, variations in the composition of the atmosphere by natural events or by human intervention, changes in atmospheric dust and particles related to volcanic activity, deviations in the ocean currents (which strongly influence coastal climates), waxing and waning of the polar icecaps, factors affecting cloudiness, variations in the earth's orbit around the sun, and fluctuations in atmospheric flow patterns not attributable to external circumstances.



One aspect of the subject of climatic change is that with a single planet the only way to test a theory rigorously is to tinker with the environment and that, as we are increasingly aware, is dangerous. So we fall back on the broader tapestry of the solar system for some help. If we have sufficiently understood our own global atmospheric phenomena, then the same ideas should be applicable to the different circumstances of another atmosphere, and if the theories work out, we may feel confidence in our initial terrestrial conclusions.

Mars, Venus, and Earth offer some important quantitative similarities and differences. The earth's rotation is an essential element in mid-latitude weather. Mars rotates at about the same rate as the earth, but Venus scarcely rotates at all. Atmospheric chemical composition may affect the surface temperature, some aspects of atmospheric motions, and cloud formation. The earth's atmosphere consists principally of oxygen and nitrogen, while the atmospheres of Mars and Venus have carbon dioxide as their principal constituent. Clouds are a crucial element of climate: Mars has only rare condensation clouds; Venus is totally covered by clouds; and the earth is halfway between, with clear

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Pueblo Bonito, an uninhabitable ruin in the Four Corners area of the Southwest, was a thriving communal Indian dwelling place in A.D. 1000. Failure of the water supply in the eleventh and twelfth centuries forced the inhabitants to migrate.

and cloudy skies in almost equal amounts. Surface pressure determines the degree of temperature contrast between the equator and the poles. With respect to the earth, Mars has less than a hundredth part of the surface pressure, while Venus has almost one hundred times as much.

This recitation of similarities and differences could continue, but I believe that I have made my point. We will therefore go on to the next stage and describe, by means of examples, a number of areas in which the behaviors of planetary atmospheres are helping to instruct us about the earth.

The first concerns the difference in temperature between the equator and the poles. The question is not why the equator is hotter. This is a matter of geometry, which can be



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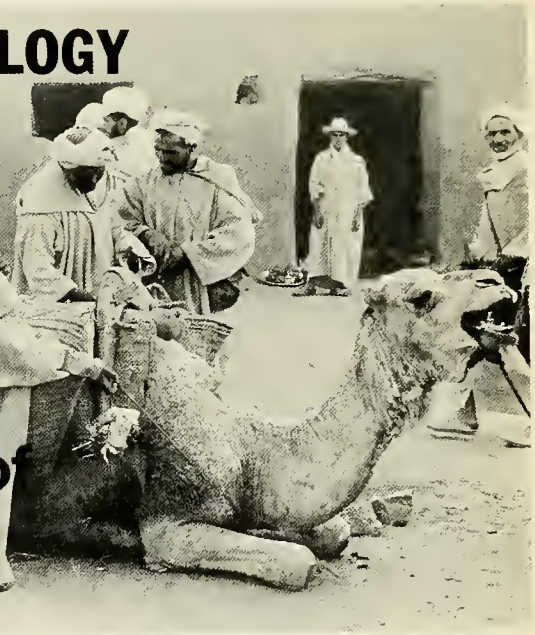
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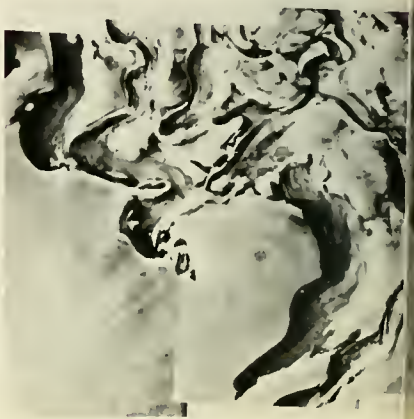


A Martian dust storm, about 186 miles across (indicated by arrow), was photographed by Viking 2. *Local dust storms, such as this one, can spread over the entire planet, thereby producing climatic change.*

determined by looking at a globe, remembering that the sun's rays strike approximately at right angles to the axis of rotation for all three planets. The amount of radiation falling on a given area of a planet's surface varies with the obliquity of the sun's rays. A large amount of solar radiation is absorbed in the tropics but where the sun's rays pass tangentially (somewhere in the polar regions) a minute amount of sunlight warms the surface.

In the simplest case, surface temperature should follow the amount of sunlight. If there is no sunlight, the temperature can sink to absolute zero, −273°C (−460°F). Thus, for a planet without atmosphere or oceans, we might expect the temperatures to vary from absolute zero at the poles to a few hundred degrees above absolute zero in the tropics. In fact, the temperature of the earth's surface varies by only 15 percent with respect to its mean value between the equator and the poles or, to put it another way, temperatures in the polar region are 200° or so above the anticipated absolute zero. Our picture must therefore be deficient in some important regard. What has been omitted is that both the atmosphere and the oceans carry heat in large amounts, tending to equalize the temperatures in equatorial and polar regions. That raises the question, What is it that governs the ability of an atmosphere to compensate differences in solar radiation by means of atmospheric mixing?

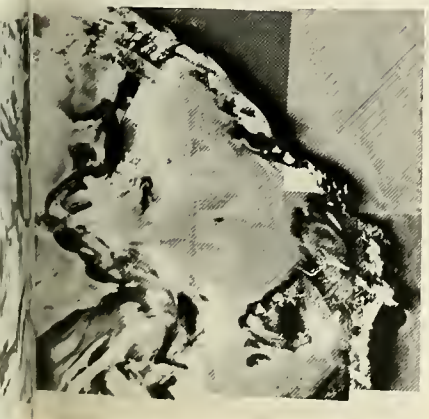
The reason I have asked this question is that it was not asked at all prior to the availability of data from Mars and Venus. These data show that the equator-to-pole tem-



perature contrast on Venus is less than 2 percent, close to that expected for an intensely stirred atmosphere. Mars, on the other hand, has a temperature contrast of 40 percent, well on the way toward the case of an airless body.

There are many factors involved in a complete explanation of these data, but the dramatic differences exhibited encourage a search for the simplest connection between the three planetary atmospheres. The essence of the argument can be captured as follows: The ability of an atmosphere to equalize temperatures by mixing does not depend on the mass of the atmosphere if the velocities involved in the mixing are comparable. On the other hand, the change in temperature that will take place in response to a change in insolation, or received solar radiation, is inversely related to the atmospheric mass. If these two processes conflict, as is the case in the three planets under discussion, the effect of differential solar heating will be less on the planet with the more massive atmosphere. The global temperature contrasts and the surface pressures of Mars, Earth, and Venus are related precisely in the sense that this argument suggests, that is, the larger the surface pressure, the smaller the temperature contrast.

This photomosaic made from photographs taken by Viking 2 *shows the Martian north polar icecap. Although water does not now exist in liquid form on Mars, there is evidence that it probably once did.*



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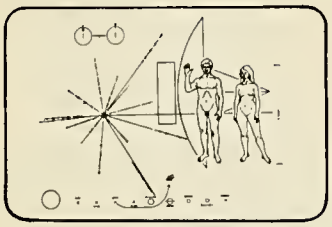
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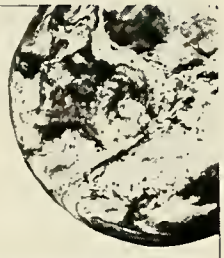
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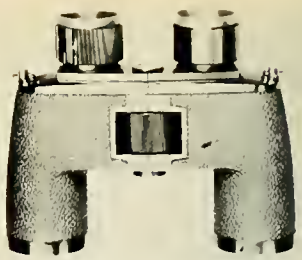
I will now turn to a second example. If we reduce the solar radiation reaching the earth's surface, the surface will cool; a 1 percent decrease in solar radiation could cause the surface temperature to decrease by about 1°C. We have already seen how small temperature changes are associated with major climatic events. A decrease of solar radiation by 10 to 15 percent could cause an ice age.

One way to vary the amount of solar radiation is to reflect some of it back into space from suspended particles. Clouds are a case in point. The loss of heat below a cloud deck, as contrasted to a clear sky overhead, is very evident to any sunbather.

Other particles, solid or liquid, can perform the same function as clouds. A permanent veil of dust in the air, such as that from volcanic eruptions, can lead to a lowering of the surface temperature. Major volcanic explosions, such as Krakatoa in 1883, Pelee in 1902, and Mount Agung in 1963, injected vast amounts of dust into the stratosphere, where it spread over much of the globe, causing spectacular twilight colors for several years. Some believe that increases in volcanic activity could have caused the Pleistocene glaciations. I tend to favor another explanation, but that does not reduce the importance of understanding this phenomenon, particularly since atmospheric dust is also a byproduct of the industrial age and the artificial could eventually exceed the natural variety.

One long-lasting effect of a volcanic eruption comes from the sulfur in the emitted gases. This sulfur goes through a series of reactions and eventually forms sulfate compounds. These compounds collect as a long-lived layer in the lower stratosphere that might have significant climatic results. The sulfate layer exhibits itself as a subtle effect in the twilight, known as the "purple light," when the sun sets some 4° below the horizon. The sulfate layer seems to persist between volcanic events but it then consists primarily of drops of concentrated sulfuric acid. This explanation comes straight from our experience with the clouds of Venus.

It is very difficult to calculate the composition of particles in a cloud without direct *in situ* measurements, and it required a mixture of



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good fortune and very careful observation to reach the present consensus that the clouds of Venus consist of small drops of concentrated sulfuric acid. That discovery was regarded as somewhat bizarre, as was the terrestrial sulfate layer discovered some decades previously.

How did such a strange substance as sulfuric acid come to form a continuous cloud layer? The surface of Venus is very hot; at 700° absolute it should be a visible dull red. This circumstance led investigators to think out from first principles what chemical species might occur if the surface of Venus were similar in composition to that of the earth. One result of this discussion was to predict the existence of an obscure substance, carbonyl sulfide, a figment of the imagination at this stage, for we have, as yet, no chemical measurements of the lower atmosphere of Venus. Nevertheless, its hypothetical existence fits with the presence of sulfuric acid clouds since there is a predictable scheme of chemical reactions that could lead from carbonyl sulfide to sulfuric acid at the observed cloud levels.

The final chapter in this story was the recent discovery of minute traces of carbonyl sulfide in the earth's atmosphere and the immediate analogy that could be drawn with Venus in order to explain the earth's sulfate layer.

Changing topics again, we may consider the more speculative, but far more dangerous, possibility of a climate catastrophe; that is, that our planet could, perhaps suddenly, change to a completely different condition.

One important possibility, at least as a "mind experiment," is that the terrestrial oceans might freeze over. I find it somewhat surprising that the geologic record contains no evidence for such an event. On the contrary, it appears that glaciations were rather rare, there being only one other previous to those of the Pleistocene epoch. I find this surprising for two reasons. First, astronomers are rather certain that the sun was cooler in earlier epochs than it now is. Second, if one accepts the arguments of Budyko, the Soviet geographer, a very small decrease in solar radiation could cause the polar ice sheet to spread to the equator.



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The reason for this is simple. We have already discussed how a decrease in solar radiation leads to a decrease in temperature and how clouds might bring about such a decrease. Now substitute snow and ice cover for clouds and we see how a protracted cold period could lead to a surface that reflects much more solar radiation than do either the continents or the liquid oceans at the present time. Even without a decrease in solar radiation, it is conceivable that if the oceans were once to freeze, they would reflect so much radiation back into space that they might not melt again.

This is not a wild speculation but a plausible conclusion, even though the scarcity of major glaciations exhibited in the earth's geologic record suggests that the reasoning is faulty. If we look elsewhere to see whether climate catastrophes are possible, traces of one can readily be seen on the surface of Mars.

Mars is colder than the earth; water does not exist there as a liquid but rather as permafrost, small polar icecaps, and possibly as large subsurface ice deposits. Even if the temperature were to rise above the melting point for ice, the atmospheric pressure is too low to allow liquid water to exist; instead, it would boil and enter the atmosphere as vapor. There is, however, spectacular evidence suggesting that liquid must have flowed over the surface of Mars on some occasion in its 4.5-billion-year history, and water is the only likely candidate. The implication is that, at one time, conditions on Mars must have differed greatly from those that are now observed. The evidence points to a climate catastrophe.

There is another and even more disturbing climatic possibility, which planetary research may help to clarify, the so-called runaway greenhouse effect. The question under consideration is whether the surface of the earth could ever become like the surface of Venus, where the temperature is high enough to melt lead and all life, as we know it, is impossible. To answer this we must attempt to understand why Venus is as it is.

The runaway greenhouse phenomenon concerns the effect of atmospheric water vapor and carbon dioxide upon surface temperature. Both gases are transparent to solar radiation and do not interfere with its absorption at the planet's surface. They are not, however, transparent to the thermal infrared radiation emitted by the surface, which in the long run balances the incoming solar radiation. This semitransparent gaseous screen intercepts some of the outgoing thermal radiation and the surface must become hotter and emit more radiation to balance the incoming solar heat. Thus, the more water vapor or carbon dioxide in the atmosphere, the higher the surface temperature.

Yet another connection between surface temperature and vapor pressure exists, namely, that the pressure of the vapor above a liquid surface increases as the temperature increases. This is why clothes dry more readily when heated and why water will boil if the temperature is high enough. As the temperature rises, therefore, the amount of water vapor above a water surface increases and the greenhouse effect then leads to a higher temperature, hence to a higher vapor pressure, and so on—each boosting the other in turn. Detailed calculations are required to understand whether this chain reaction tends toward a steady condition, as in a nuclear reactor, or toward a runaway condition, as in an atomic bomb.

The answer depends upon how close we are to the sun. It appears that there is a critical distance from the sun, somewhere between that of Earth and that of Venus, that enables us to enjoy a controlled situation while Venus undergoes its present inhospitable runaway condition.

If all this is correct, we may be dangerously close to disaster. Relatively small changes in the amount of our clouds, the nature of our surface, or the chemical composition of our atmosphere could bring us closer to Venus's condition. There is no reason that we know of to take alarm at this circumstance, but every reason to investigate our nearest neighbor with great care.

My final vignette concerns dust storms. You should be convinced at this point that dust in the atmosphere can affect the climate in an important way, and a number of human activities can influence this



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factor: overgrazing, irrigation, industrial effluents, and photochemical smogs, to name a few. One problem is that winds can raise dust, which can then change the weather and thereby influence the dust amount. How do these processes interact and could they, like the ice cover or the greenhouse effect, run away in an uncontrolled manner?

We have not gotten very far with this question in terms of terrestrial happenings, but the global dust storms of Mars present us with spectacular and possibly related events to study.

The atmosphere of Mars is usually fairly clear. It is true that it contains a larger amount of dust in proportion to gas than does the earth. It was a minor surprise of the *Viking* mission (although it should not have been) that the Martian sky is colored red by the dust rather than being blue, as in the scattering by gaseous molecules on the earth.

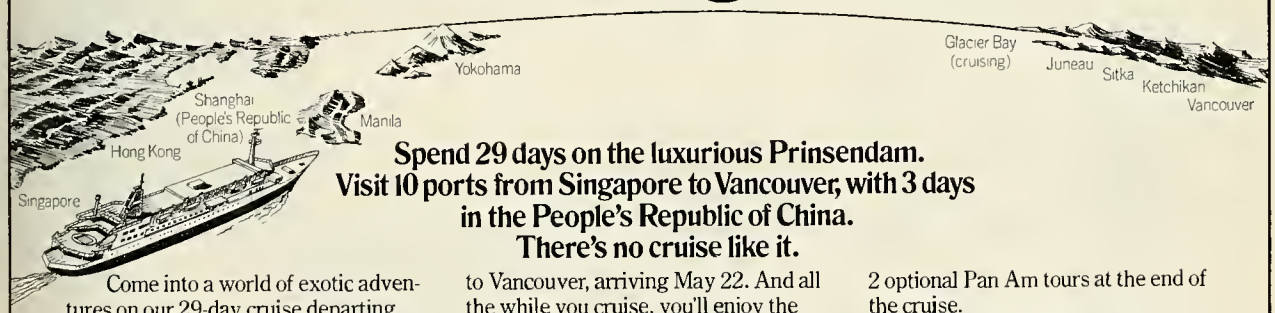
The dust suspended in the Martian atmosphere can absorb solar radiation, and since there is so much dust in relationship to the tenuous atmosphere, the heating rate can be very great. It can go as high as tens of degrees in a single day, a rate that typically occurs in a terrestrial hurricane. In the latter case, the heating is caused by condensing water, but the effect is similar; namely, that a substance, water or dust, is raised from the surface and then rapidly heats the atmosphere. In either event the heat released can drive a gigantic heat engine fueled by the materials raised by its own winds. The engine can, therefore, sustain itself and build up to dangerous intensities.

There is an important difference, however, between a hurricane and a large dust storm—the condensed water of a hurricane falls out rapidly as rain, while dust can linger in suspension for days or weeks. A Martian dust storm can continue to pump dust from the surface until the stratosphere over the entire planet is filled. Thus when *Mariner 9* reached Mars in 1971, the planet's surface could not be seen; only three large volcanoes showed as traces on the television images. Fortunately, the dust settled after a week or two and the *Mariner* cameras could carry out their mapping mission according to plan.

The most recent *Viking* pictures capture examples of some small dust storms and of one storm that achieved global proportions. We do not have all the data needed to understand these events but the potential for uncovering clues in a class of climate problems is enough to justify careful comparative studies of Martian and comparable terrestrial phenomena.

I have tried to show how ideas can move back and forth between planetary and terrestrial atmospheric problems to the benefit of both subjects. In fact, they are not two subjects, but one. Lest I be misunderstood, I do not suggest that planetary research should be chosen as the main approach to all or any terrestrial climate problems. At best, we gain inspiration from such studies. The required answers to specific questions about climate must also be reachable without the use of space probes. Nevertheless, the knowledge gained from planetary exploration can help us better understand some terrestrial problems and I, for one, greatly appreciate that bonus. □

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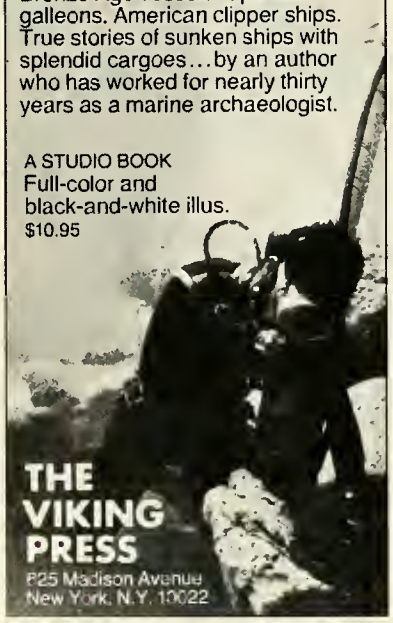
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The Human Condition

HUMANKIND, by Peter Farb. *Houghton Mifflin Company, $15.95; 544 pp., illus.*

Sydney Smith, English wit and writer of the early nineteenth century, was asked by a froward young lady at a dinner party whether he read the books he reviewed. Whereupon Smith replied, "Dear me, no. It prejudices a man so." I must confess that after reading the first ninety pages of this magisterial work, it was clear to me that if the author maintained the same rate of error, skewness, and misinterpretation throughout the book, I should not be sufficiently able to unprejudice myself in favor of its good qualities to recommend it to the attention of the reader.

But after that small segment of ninety pages it is as if the author had suddenly found his way out of the darkness into the broad light of day, for in the remainder of the book virtually all error, skewness, and misinterpretation fall away, and one finds oneself cheering the author's success in bringing off a feat that I, at least, can only marvel at. "And still the wonder grew/ That one small head could carry all he knew." Not that the remainder of the book is totally free of errors, but they are of a trivial nature and none of them significantly affect the point the author is making. However, lest the reader feel disappointed, here is a brief sample taken at random. The term *Ramapithecus* is not derived from two Greek words. One-egged twins should not be called "identical" because they can be both chromosomally and constitutionally different. No human has ever been born with a genuine tail. Darwin did have a retarded son. It does not cost $200,000 to raise a child from conception through four years of college, but by the latest (October 1977) estimate, $64,000. And so on. This small sampling will do. The reader will perceive that the type of error cited is really of no great moment. And so let us proceed to the book itself.

What Farb has attempted to do in this book is to give the reader something more than the usual superficial account of the rise and development of humankind. He succeeds where others have failed because he continually probes beneath the surface in the endeavor to find the causes of things. He never glosses. He goes into detail. When he doesn't know, he says so. He has read widely and well, and he possesses the gift of writing clearly and simply. One is never at a loss to understand what he means. There is not a dull page in the book. In fact, I found it so absorbing that it was difficult to attend to anything else until I had completed reading it. And, indeed, when I came to the end I regretted that this quite long book was not longer.

Humankind not only makes delightful and informative reading, it constitutes a liberal education in itself. I cannot think of another work that comes close to what Farb has achieved in this book. Although this certainly was not his purpose, one of the things his book should accomplish is to make it clear that anthropology, the study of humanity, should be at the core of every educational curriculum, embellished, of course, by the satellite humanities. *Humankind* would be the ideal text for such a core curriculum.

As Farb puts it, the book represents "an attempt to solve some of the mystifying unknowns in the human equation, to examine the axioms and postulates about our biology and behavior, and from these variables to deduce at least some understanding of our past and our future." He begins by placing humankind within its proper framework in our world and discussing

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This year, the Grand Prize of *Natural History*'s photographic competition will be two tickets for the American Museum of Natural History's Discovery Tour of Egypt. The three-week trip will include a two-day stop in London, followed by a leisurely cruise on the Nile from Cairo to Aswan, with an optional flight to Abu-Simbel.

Besides the Grand Prize, the 1978 competition offers cash prizes totaling more than $3,000. The winning entries will be published in a special double issue of *Natural History* in August and will be exhibited at the American Museum of Natural History.

The four categories for entries are broad enough to fit the interests of any photographer. They are: (1) The Natural World; (2) A Sequence of an Event in Nature; (3) Photomicrography, including pictures with a scanning electron microscope; and (4) The Human Environment. First Prize in each category is $500. In addition, all entries are eligible for the following awards: Humor in Nature, $200; Urban Wildlife, $200; and ten Honorable Mentions at $100 each.

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To all, the best of luck!



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the importance of the meaning of our membership in the order of primates for an understanding of our rise and development. Here, among other things, Farb underscores that humans apparently represent the only species that has ever been threatened by its own biological success. But he also shows that it is the retention of that remarkable plasticity, that flexibility characteristic of humankind, that constitutes the saving hope for our species.

Indeed, as we read *Humankind* the feeling grows upon us with ever firmer conviction that if we work hard enough at what needs to be done, we shall not only emerge triumphant from our present confusions but also that the best in us may yet prevail. In this connection, I would have wished that Farb had emphasized that it is not the misconceived idea of "the survival of the fittest" that will always remain the vital principle for *Homo sapiens,* but rather "the survival of the fit." In a world as complex as ours, the fittest don't stand a chance, for the simple reason that they tend to be too specialized, whereas the fit, by virtue of their plasticity, are much more likely to make the appropriate adaptive responses to the challenges of the environment. The trait that especially distinguishes humankind from every other kind of creature, living or extinct, is its polymorphous educability. Whatever it is possible to learn, humans are everywhere capable of learning. And, as Farb emphasizes, one has to learn to be human.

The potentialities for being human are, of course, uniquely given in the genetic constitution of the species, but to become actively human one has to learn from other humans. While other organisms adapt to their environments through changes in their genes as a result of selective pressures from the environment, humans have the remarkable capacity to make adaptive changes by changing the environment to fit their genes. The changes that will fit the genes, within the limits of what is possible, are quite unrestrictable.

I am glad that Farb says without equivocation that "humans are not believed to possess instincts," and twenty pages later to write that "humans have replaced instincts by social inhibitors, and so adult hu-

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Linus Pauling, Ph.D.

VITAMIN C AND HEART DISEASE

Can vitamin C protect you, and how much should you take?

Heart disease and related diseases of the circulatory system are the main cause of death in the United States. Over one million people die of these diseases each year, and probably more than five million people now living are suffering from them in a significant way.

There is no doubt that heart disease is related to the diet. In the 1976 Congressional Hearings on the relation between diet and disease the nation's top health officer, Dr. Theodore Cooper (Assistant Secretary for Health in the Department of Health, Education, and Welfare), stated that

> "While scientists do not yet agree on the specific causal relationships, evidence is mounting and there appears to be general agreement that the kinds and amount of food and beverages we consume and the style of living common in our generally affluent, sedentary society may be the major factors associated with the cause of cancer, cardiovascular disease, and other chronic illnesses."

For about 25 years the major culprits in cardiovascular disease have been thought to be saturated fats, cholesterol, and related fat-like substances (lipids). A tremendous campaign has been waged to promote diets with low cholesterol, low saturated fat, and increased polyunsaturated fat. Despite this campaign, the death rate from cardiovascular disease has remained constant during the last 25 years, and it now seems to be almost certain that the assumption that heart disease is caused by a high intake of saturated fats and cholesterol is wrong.

This development does not mean that diet is not important. A high intake of ordinary sugar greatly increases the incidence of cardiovascular disease (see "Sugar: Sweet and Dangerous" in *Executive Health*, Volume 9, Number 1, 1972). Moreover, much evidence has been gathered recently to show that cardiovascular disease can be controlled to a considerable extent by the proper use of vitamin C.

What is cardiovascular disease?

The general term cardiovascular disease comprises various diseases of the heart and blood vessels. Arterio-

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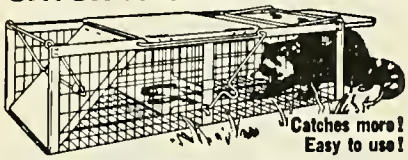
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mans are not under the control of any instincts whatever."

Instinct as an explanatory principle has served so long to explain so many different forms of behavior that it has grown to be uncritically accepted as an article of faith. Faith is certainty without proof; science is proof without certainty. The amusing thing about the debate over instinct in humans is that it could be easily settled, but it hasn't been. One would suppose that one could simply cite examples of instincts in humans and measure them by whatever means had been agreed upon for their existence or nonexistence.

If one can avoid the semantic confusion of such things as "drives," "reflexes," "predispositions," "needs," "the innate," and the like, there is some chance that one may understand why the so-called sex instinct and Lorenz, Ardrey and company's much-bruited "instinct of aggression" are not instincts at all. As Farb puts it, "Humans survive as a result of the things they are able to learn, not the things they are born with."

Both the interest and the value of his book would have been heightened had Farb devoted some space to a critical discussion of the fallacies involved in the claims usually made for the existence of instincts in humans. The meaning of a word is the action it produces, and in this area the divine right of words has played a dominant role. Words fashion our thoughts, and in this way, alas, we become the prisoners of other peoples' vocabularies. I wish that, in his excellent discussion of language, Farb had said something on this theme. Let us, however, be grateful for what he has given us in such abundance, for his ideas, at least, are never buried in thickets of words.

In his wholly admirable discussion of the chimera of "race," Farb makes a point that is too frequently overlooked, namely, that biological and physical differences between human populations are often equated with imputed, innately determined psychosocial differences. It is the practice of this imputation that is the essence of racism. Racism, as Oliver Wendell Holmes, Sr., said, is like the pupil of the human eye: the more light you expose it to, the narrower it grows. The ringing words of William Lloyd Garrison reverberate in the mind. "With reasonable men I will reason; with humane men I will plead; but to tyrants I will give no quarter, nor waste arguments where they will certainly be lost."

Farb will not be read by bigots, racists, or tyrants. His book will be read by reasonable and humane men and women, for it is a reasonable and humane book about humanity, and it is qualifiedly optimistic concerning the future of our species. My own view is that, in a time of crisis, the only philosophically tenable position—even for a pessimist—is optimism. Farb concludes that our species has always been beset by problems and has always produced innovations to solve them. And he adds, "No reason whatever exists for doubting that such will continue to be the case in the future." Had he thought otherwise, he would not have written this book. I, for one, am very glad he saw fit to write it.

Ashley Montagu is a noted anthropologist and social biologist whose most recent book is The Nature of Human Aggression.

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Celestial Events

Thomas D. Nicholson

Sun and Moon From the beginning of January until about the 19th, the sun moves eastward through the stars of Sagittarius, then enters Capricornus. In this part of its easterly journey, the sun moves nearly parallel to the equatorial plane; from winter solstice on December 21 until the end of January, it moves only five degrees northward. But because of our time-keeping practices, the time of sunset is affected more than that of sunrise. Sunset in late January comes conspicuously later than at winter's beginning, but the time of sunrise has hardly changed.

The evening sky (before midnight) will be dark and moonless for the first two weeks of January, but from midmonth until the last week, the moon will notably brighten the evenings. In particular, observe the effect of the full moon on the nights of the 23rd and 24th, when its high, long path will light up the long, cold January nights. Phases are: last-quarter on January 2, new on the 8th, first-quarter on the 15th, full on the 24th, last-quarter again on the 31st. The moon in February will be new on the 7th, at first-quarter on the 14th.

Stars and Planets Three bright planets, all on the evening Star Map, appear prominently among the evening stars this month. Brightest is Jupiter, in Gemini, about midway between the twin stars, Castor and Pollux, and Aldebaran (in Taurus), low in the east at dusk, high in the south before midnight. Mars, now quite bright and reddish in color, is to Jupiter's left, among the dim stars of Cancer. It rises approximately at sunset and sets at about sunrise. If you watch carefully from night to night, you will see its rapid retrograde (westward) motion through the stars of Cancer. Saturn is to the left of Mars, very close to Regulus in Leo (Saturn is the object to the right). It rises early at night and is high in the south after midnight.

January 1: Earth is at perihelion, nearest to the sun for this year.

January 3: The moderately productive (40 per hour) Quadrantid meteor shower will be at maximum this morning.

January 5: The latest sunrise of the year occurs.

January 8: The moon is at perigee. The effects of perigee and perihelion will enhance the spring tides that coincide with the new moon occurring later today.

January 18: Mars is now nearest the earth. It reaches this position once every 26 months, but its distance from earth at such times may vary from about 35 to 63 million miles because Mars can be at any location in its eliptical orbit.

January 20: Saturn is nearest Regulus today (in conjunction) and moves slowly off to its right (west). The moon is at apogee.

January 21: Mars is at opposition from the sun; Venus is in superior conjunction with the sun. Technically, Mars now rises at sunset and sets at sunrise; Venus rises and sets with the sun; and both become evening stars.

January 23: Mars is near the moon tonight.

January 25–26: Saturn is near the moon on these evenings.

February 5: The moon is at perigee.

February 15: The moon is very close to Aldebaran tonight. At about 9:00 P.M., EST, it is so close that it covers the star (an occultation) for observers in parts of North America and Europe. Saturn is at opposition from the sun tonight and becomes an evening star.



* Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:15 P.M. on January 1; 10:15 P.M. on January 15; 9:15 P.M. on January 31; and 8:15 P.M. on February 15; but it can also be used for an hour before and after those times.



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Additional Reading

Tovil Dance (p. 42)

Richard F. Gombrich's *Precept and Practice: Traditional Buddhism in the Rural Highlands of Ceylon* (New York: Oxford University Press, 1971) places the *tovil* ceremonies in their Buddhist context, explaining the relationship between culture and religion. The same approach is taken on a more general level by David G. Mandelbaum in "Transcendental and Pragmatic Aspects of Religion," *American Anthropologist,* vol. 68 (1966), pp. 1174–91. For the Sinhalese, Michael M. Ames describes the combination of religious and medical therapy in "Magical-Animism and Buddhism: A Structural Analysis of the Sinhalese Religious System," *Journal of Asian Studies,* vol. 23 (1964), special issue, pp. 21–52, and in "Buddha and the Dancing Goblins: A Theory of Magic and Religion," *American Anthropologist,* vol. 64 (1964), pp. 75–82.

Gananath Obeyesekere has studied Sinhalese rituals closely for many years. Two of his more important contributions are "The Buddhist Pantheon in Ceylon and Its Extensions," Yale University, *Southeast Asia Studies, Cultural Reports Series,* no. 13 (1966), pp. 1–26, and "The Ritual Drama of the Sanni Demons: Collective Representations of Disease in Ceylon," *Comparative Studies in Society and History* vol. 11, no. 2 (1969), pp. 174–216. Paul Wirz's *Exorcism in the Art of Healing in Ceylon* (Leiden: E.J. Brill Publications, 1954) contains descriptive details of the *tovil* ceremonies. Beryl De Zoete also describes the ceremonies in *Dance and Magic Drama in Ceylon* (New York: Theatre Arts Books, 1958; $4.50).

Nubian Ibex (p. 50)

The *Mammals IV* volume of *Grzimek's Animal Life Encyclopedia,* edited by Bernhard Grzimek, gives information about the different varieties of ibex. The English-language edition of this work was published by Van Nostrand Reinhold Company of New York in 1972. *Hoofed Mammals of the World,* coauthored by artist Ugo Mochi and scientist T. Donald Carter (New York: Charles Scribner's Sons, 1971) contains more basic information and shadow drawings for each species described.

In "The Behavior of Ungulates and Its Relation to Management," (pp. 324–40 of *IUCN New Series Publication No. 24,* 1971) Bernard Nievergelt compares rutting behavior and grouping in the Ethiopian and Alpine ibex. This IUCN publication is a result of an international symposium held in Calgary. Verna Mays gives a short history of the renewal of the depleted ibex populations of Europe in "With a Little Bit of Luck" in *International Wildlife,* 1973, vol. 3, no. 1, pp. 28–31.

Parthenogenetic Lizards (p. 56)

Various modes of reproduction are discussed in *Intersexuality in the Animal Kingdom* (New York: Springer-Verlag, 1975), edited by Rudolf Reinboth. This collection of articles, which resulted from a symposium held in Mainz in 1974, includes chapters on invertebrates, fish, amphibians, reptiles, birds, and mammals; in the section on reptiles, Charles J. Cole reviews current knowledge of all known species. The book has extensive bibliographies and illustrations.

Much of the recent work on parthenogenesis in lizards has not yet filtered into the popular literature. For the reader who has access to a larger library or who wishes to obtain interlibrary loans, the following important contributions are listed. The question of natural parthenogenesis in lizards was first raised by Ilya S. Darevsky, whose early work on Armenian lizards is summarized in a 1966 article, "Natural Parthenogenesis in a Polymorphic Group of Caucasian Rock Lizards Related to *Lacerta saxicola* Eversmann" (*Journal of the Ohio Herpetological Society,* vol. 5, no. 4, pp. 115–52). Thomas Uzzell and Darevsky have more recently (1975) presented "Biochemical Evidence for the Hybrid Origin of the Parthenogenetic Species of the *Lacerta saxicola* Complex (Sauria: Lacertidae), with a Discussion of Some Ecological and Evolutionary Implications" (*Copeia,* no. 2, pp. 204–22). J.W. Wright and C.H. Lowe hypothesize the hybrid origin of parthenogenetic species of American lizards in "Weeds, Polyploids, Parthenogenesis, and the Geographical and Ecological Distribution of All-Female Species of Cnemidophorus" (*Copeia,* no. 1, pp. 128–38). Robert L. Bezy discusses the origin of parthenogenesis in the absence of hybridization in "Karyotypic Variation and Evolution of the Lizards in the Family Xantusiidae," *Natural History Museum of Los Angeles County Contributions in Science,* no. 227 (1972), pp. 1–29.

Crickets (p. 64)

Richard Dawkins, an ethological theoretician at Oxford University, presents a new perspective on evolutionary biology in *The Selfish Gene* (New York: Oxford University Press, 1976). Dawkins contends that the gene, rather than the species, is the principal factor in natural selection. One of the chapters in Howard E. Evans's *Life on a Little-Known Planet* (New York: Dell Publishing Co., 1968, $2.45 in paperback) is entitled, "The Cricket as Poet and Pugilist." In entertaining form, Evans runs down the history of cricket study, including a summary of the literature on singing and sexual behavior. Cricket songs are included among the noises of *The Songs of Insects,* by Richard D. Alexander and Donald J. Borror (one of the pioneers in the recording of insect and bird sounds). This disc, produced in 1956 by Cornell University Press, has been distributed since 1966 by Houghton-Mifflin Co. of Boston.

In "Aggressiveness, Territoriality, and Sexual Behavior in Field Crickets (Orthoptera: Gryllidae)," *Behaviour,* vol. 17 (1961), pp. 130–223, Richard D. Alexander established that crickets are aggressive. His "The Evolution of Cricket Chirps," which appeared in *Natural History,* November 1966 (pp. 26–31), includes such biological information as the anatomy of the sound-making apparatus and the effects of temperature on chirping behavior. "Natural Selection and Specialized Chorusing Behavior in

Acoustical Insects," a chapter in *Insects, Science and Society*, edited by David Pimental (New York: Academic Press, 1975), is Alexander's review of work carried out by himself and others during the past twenty years. This chapter includes an excellent bibliography, as does "Effects and Functions in the Evolution of Signaling Systems," Specialized Chorusing Behavior in *Ecology and Systematics*, vol. 5 (1974), pp. 385–417. Otte's is a similar, but slightly broader, review article. A source for examples of mating systems and sexual selection among many different groups of insects is *Reproductive Competition, Mate Choice and Sexual Selection*, edited by Murray Blum (New York: Academic Press, in press).

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Roy Rappaport explains his version of the concept of "ritual" in "Obvious Aspects of Ritual," *Cambridge Anthropology*, vol. 2, (1974), pp. 2–60. In "The Great American Football Ritual," (*Natural History*, October 1975, pp. 72–81), William Arens contends that football contests are fair game for anthropologists. Arens and Susan Montague have edited a collection of articles, *The American Dimension: Cultural Myths and Social Realities* (Port Townsend: Alfred Publishing Co., 1976), whose central theme is the anthropologically oriented study of contemporary American culture. This $5.95 volume covers such topics as the symbolic meaning of soap operas and commercials, the cultural characteristics of Nancy Drew and the Hardy Boys, and coffee drinking and rock music as particularly American institutions.

Ray Kroc, who is to McDonald's what Walt Disney was to Disneyland, has become a personality of interest. Kroc has recently produced an autobiography entitled, *Grinding It Out* (Chicago: Henry Regnery Co., 1977). *Big Mac: The Unauthorized Story of McDonald's*, by Max Boas and Steve Chain (New York: E.P. Dutton & Co.), takes another biographical viewpoint. It is available for $8.95.

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Announcements

Museum visitors can get a close-up look at the **Small Animals of Trinidad** on February 1, at 8:00 P.M., when Ray Mendez, of the Museum's Exhibition Department, will present a slide lecture in the auditorium on some of the mammals, reptiles, amphibians, and arthropods that frequent the island's Arima Valley. Entomologist-photographer-artist Ray Mendez, has made five trips to Trinidad, where he has studied and photographed such bizarre subjects as a fungus that envelops spiders; tarantulas that live in twenty-foot-high piles of bat guano; hundreds of thousands of bats pouring out of a cave at dusk; army ants; and the world's smallest snakes, which live in huge termite nests. The event will begin with a brief discussion of Trinidad's ecology and end with a question and answer session.

Tickets for associate members and the public are $2.00 and will be available at the auditorium door half an hour before the program begins. Participating and donor members will be admitted free.

More than eighteen **Hayden Planetarium Courses** will be offered beginning in January. Included will be "Stars, Constellations and Legends," on the lore of the sky; "Science and Science Fiction"; "Going Metric"; "Ground School for Commercial and Instrument Pilots"; and a variety of courses in astronomy, telescope making, telescope using, and navigation. Tuition ranges from $40 to $75 (telescope-making materials are not included) and courses run from five to ten sessions.

For young people, four astronomy courses of varying difficulty are scheduled; each will meet ten times and cost $20.

For more detailed information about all of the special courses at the Hayden Planetarium write to the American Museum-Hayden Planetarium, 81st Street and Central Part West, New York, New York 10024 or call (212) 873-1300, ext. 206.

A small exhibit entitled **Azurite and Gold Crystals** will continue through February 1978, in the Museum's Roosevelt Rotunda on the second floor. The exhibit includes a matrix specimen of azurite from South-West Africa and a specimen of crystalized gold from California. The pieces have a combined value of $500,000.

We've Been Here 100 Years, the nostalgic photography exhibit commemorating the hundredth anniversary of the Museum at its present site, will continue through February 1978, in the Hall of Northwest Coast Indians, on the first floor of the Museum.



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February 1978

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Authors

William H. Drury is studying the ecology of marine birds in the Bering Sea as part of a National Oceanic and Atmospheric Administration (NOAA) project to assess the impact of oil drilling in the region. Drury, who teaches ecology at the College of the Atlantic in Maine, has long been interested in biogeography. While formerly serving as director of research for the Massachusetts Audubon Society, he made a ten-year study of tern and herring gull populations and movements along the New England coast. His future plans include research on the flora and fauna of Maine islands, on one of which he owns some land.





An assistant professor of geology and mineralogy at the University of New Mexico in Albuquerque, **Rodney C. Ewing**'s main diversion is "walking in the mountains with a recalcitrant dog named Kimo." The subject of symmetry first drew his attention in an undergraduate course in mineralogy. A subsequent honors seminar, in which both scientists and artists discussed their respective concepts of symmetry, further buttressed his interest. Ewing's current research involves, among other projects, a study of natural minerals that have suffered radiation damage from constituent uranium and thorium atoms. Although this is an esoteric subject, Ewing says it provides "very useful information in the evaluation of the long-term stability of material used for radioactive waste disposal."



Asen Balikci, professor of anthropology at the University of Montreal, was studying pastoral nomads in northern Afghanistan when he first saw *buzkashi* games. He subsequently filmed them as part of an anthropological series on social life in the Narin-Burka area. Besides previous fieldwork in Afghanistan and Ethiopia, Balikci has supervised the making of a nine-film series about the Netsilik Eskimo, seal hunters who live along the Canadian Arctic coast northwest of Hudson Bay. Balikci presented three films from that series at the American Museum of Natural History in February 1976.



Photojournalist **Jim Sheldon,** who spent five weeks in Afghanistan contributed research on *buzkashi* Sheldon works at the Internationa Center of Photography, New York

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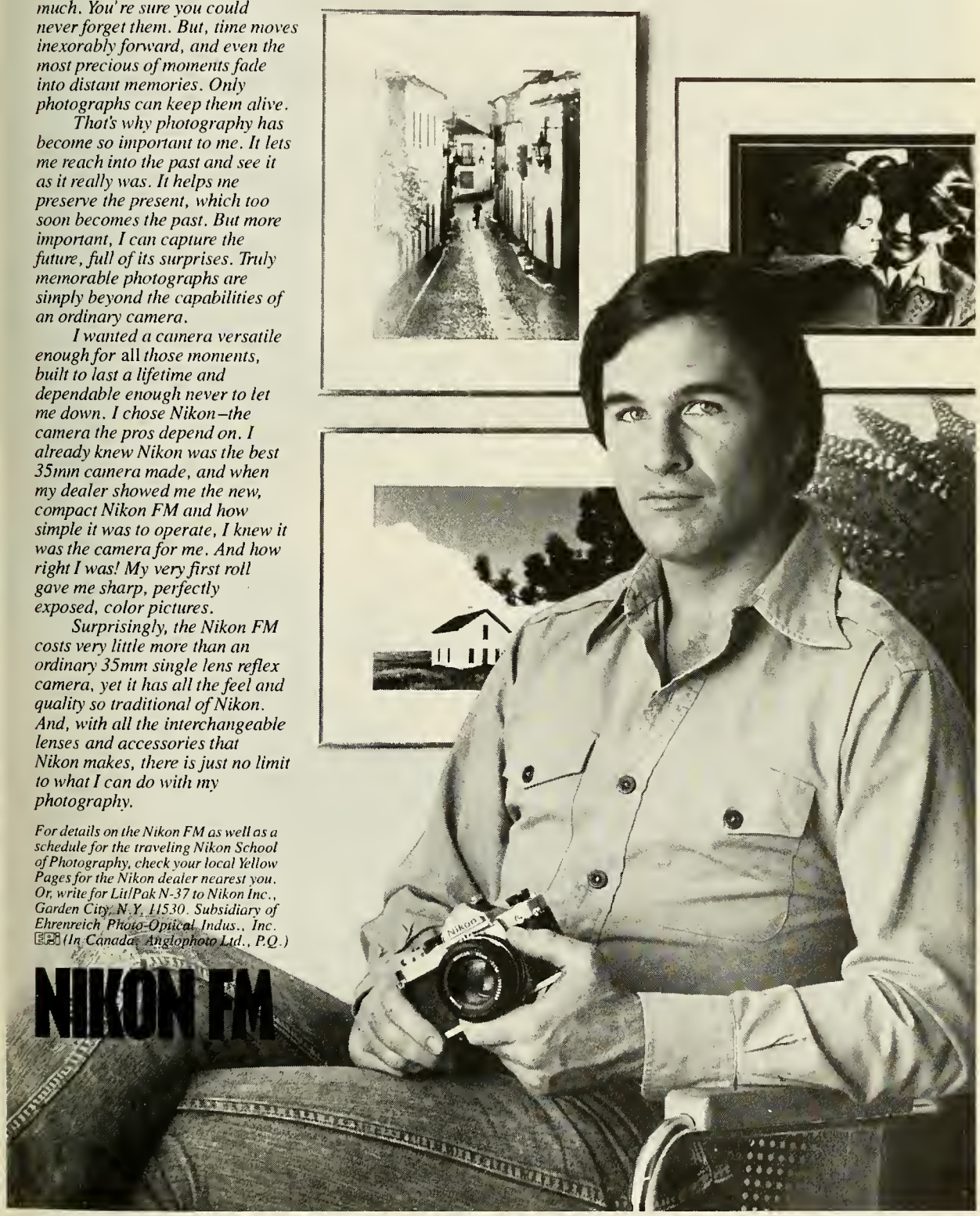
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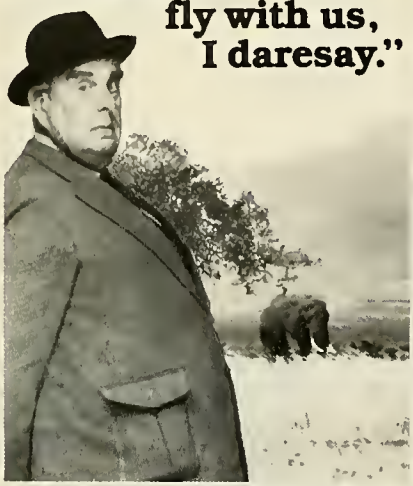
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Born and raised in Nebraska, **Marilyn Coffey,** decided to write a memoir of the Great Plains—its land and its people. The dust storms of the thirties were one of the legends of her childhood and the severity of the weather in the Midwest left a deep impression on her. Coffey, who graduated from the University of Nebraska with a bachelor's in journalism, recently received the Master Alumnus award for distinguished achievement in her field. "Badlands Revisited," a previous essay from her Plains memoir, was published in the *Atlantic Monthly*, December 1974. Coffey is an assistant professor of English at Pratt Institute in Brooklyn, where she has just moved to a house with—at last—a garret to write in.



A postdoctoral fellow at the Scripps Institute of Oceanography, **Ronald E. Thresher** is conducting surveys of reef fishes in the Gulf of California. The data he is collecting is being added to a long-term comparative study of Caribbean and eastern Pacific reef fishes. The focus of this work is the role of color patterns in social behavior. During his underwater explorations, Thresher also examines the effects of marine resources on the spacing and behavior of the blenny. In his spare time, he is a free-lance writer and raises orchids.

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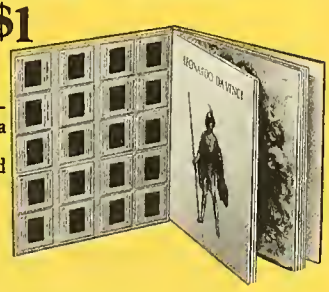
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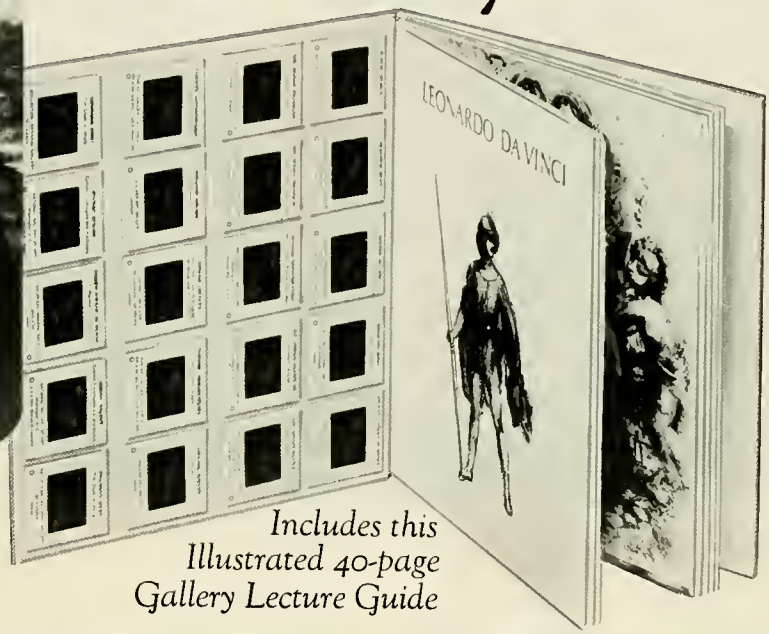
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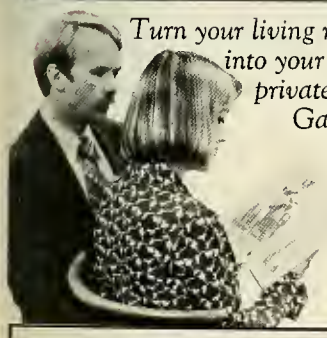
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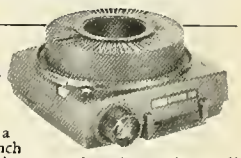
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by Stephen Jay Gould

An Early Start

Shortly after the dawn of earth, life arose with vim and vigor

Pooh-Bah, the Lord High Everything Else of Titipu, boasted a family pride so strong as to be "something inconceivable." "You will understand this," he said to Nanki-Poo in suggesting that a bribe would be both appropriate and expensive, "when I tell you that I can trace my ancestry back to a protoplasmal primordial atomic globule."

If human pride is nurtured by such vastly extended roots, then the end of 1977 was a bounteous period for self-esteem. Early in November, an announcement of the discovery of some fossil prokaryotes from South Africa pushed the antiquity of life back to 3.4 billion years. (Prokaryotes, including bacteria and blue-green algae, form the kingdom Monera. Their cells contain no organelles—no nucleus, no mitochondria—and they are regarded as the simplest forms of life on earth.) Two weeks later, a research team from the University of Illinois announced that the so-called methane-producing bacteria are not closely related to other monerans after all, but form a separate kingdom of their own.

If true monerans were alive 3.4 million years ago, then the common ancestor of monerans and these newly christened "methanogens" must be considerably more ancient. Since the oldest dated rocks, the Isua Supracrustals of West Greenland, are 3.8 billion years old, we are left with very little time between the development of suitable conditions for life on the earth's surface and the origin of life. Life is not a complex accident that required immense time to convert the vastly improbable into the nearly certain. Instead, life, for all its intricacy, probably arose rapidly about as soon as it could; perhaps it was as inevitable as quartz or feldspar. (The earth is some 4½ billion years old, but it first passed through a molten or near-molten stage and probably did not form a solid crust much before the deposition of the West Greenland sequence.) No wonder these stories hit the front page of the *New York Times*, and even inspired an editorial for Veterans' Day musings.

Twenty years ago, I spent a summer at the University of Colorado, fortifying myself for the transition from high school to college. Amidst the various joys of snowcapped peaks and sore bottoms from trying to "set a trot," I well remember the highlight of my stay—George Wald's lecture on the "Origin of Life." He presented with infectious charm and enthusiasm the perspective that developed in the early 1950s and reigned as an orthodoxy until very recently—in fact, until last month for people who rely on published reports and do not have access to the "invisible college" of primary researchers. (Here I am fortunate, for a major center of the "college" lies a hundred feet from my office, and several of its outstanding occupants are friends and colleagues.)

In Wald's view, the spontaneous origin of life was a virtually inevitable consequence of the earth's atmosphere and crust, and of its favorable size and position in the solar system. Still, life is so staggeringly complex that its origin from simple chemicals must have consumed an immense amount of time —probably more time than its entire subsequent evolution from DNA molecule to advanced beetles (or whatever you choose to place atop the subjective ladder). Thousands of steps, each requiring the one before; each improbable in itself. Only the immensity of time guaranteed the result, for time converts the improbable to the inevitable—give me a million years and I'll flip a hundred heads in a row more than once. Wald wrote in 1954: "Time is in fact the hero of the plot. The time with which we have to deal is the order of two billion years. . . . Given so much time, the 'impossible' becomes possible, the possible probable, and the probable virtually certain. One has only to wait: time itself performs the miracles."

This orthodox view congealed without the benefit of any direct data from paleontology to test it, for the paucity of fossils before the great Cambrian "explosion" 600 million years ago is, perhaps, the outstanding fact and frustration of my profession (and the subject of several past columns). In fact, the first unambiguous evidence of Precambrian life appeared in the same year that Wald theorized about its origin. Harvard paleobotanist Elso Barghoorn and Wisconsin geologist S. A. Tyler described a series of prokaryotic organisms from cherts of the Gunflint Formation, rocks nearly 2 billion years old from the northern shore of Lake Superior. Still, the gap between the Gunflint and the earth's origin spanned 2½ billion years, more than enough time for Wald's slow and steady construction.

But our view of life continued to move backward. Laminated carbonate deposits, known as stromatolites, had been known for some time from rocks of the Bulawayan Series, 2.6 to 2.8 billion years old, in Southern Rhodesia. The laminations resemble patterns formed by modern blue-green algal mats that trap and bind sediment. With fossil microorganisms clearly present in the Gunflint, the organic interpretation of stromatolites won many adherents. Then, ten years ago in 1967, Barghoorn and J. W. Schopf reported "algalike" and "bacteriumlike" organisms from the Fig Tree Series of South Africa. Now the orthodox idea of slow construction over most of the earth's history began to crumble for the Fig Tree rocks, based on dates available in 1967, seemed to be more than 3 billion years old. Schopf and Barghoorn dignified their discoveries



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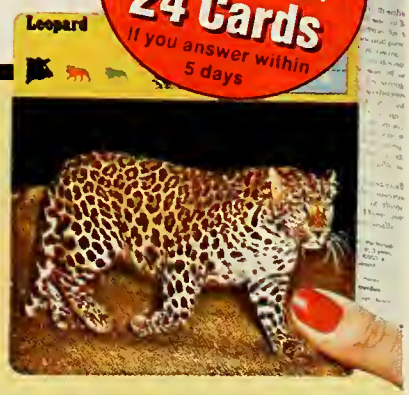
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with formal Latin names, but their own characterizations—algalike and bacteriumlike—reflected their doubts. In fact, Schopf later decided that the balance of evidence stood against the biological nature of these structures.

In this context, the recent announcement of 3.4-billion-year-old life is not a startlingly new discovery but a satisfactory culmination of a decade's debate about the status of life in the Fig Tree. The new evidence, discovered by Andrew H. Knoll and Barghoorn, also comes from cherts of the Fig Tree Series. But now the evidence is close to conclusive; moreover, recent dates indicate a greater age of 3.4 billion years for the series. The Fig Tree cherts may be the oldest appropriate rocks on earth for the discovery of ancient life. The older Greenland rocks have been too altered by heat and pressure to preserve any organic remains. Knoll tells me that some unstudied cherts in Rhodesia may range back to 3.6 billion years, but anxious scientists will have to await a political denouement before their arcane concerns attract sympathy or safety. Still, the notion that life has been found in the oldest rocks that could contain evidence of it forces us, I think, to abandon the view of life's slow, steady, and improbable development. Life arose rapidly, perhaps as soon as the earth cooled down sufficiently to support it.

The new evidence from the Fig Tree Series consists primarily of algalike microstructures far more convincing than the previous discoveries. "In younger rocks [they] would without hesitation be called algal microfossils," Knoll and Barghoorn claim. This interpretation rests upon five arguments:

1. The new structures are within the size range of modern prokaryotes. The earlier structures described by Schopf and Barghoorn were disturbingly large; Schopf later rejected them as biological primarily on the basis of their large size.

2. Populations of modern prokaryotes have a characteristic distribution of size. They can be arranged in a typical bell-shaped curve, with the average diameter most frequent and a continual decrease in numbers as we move to



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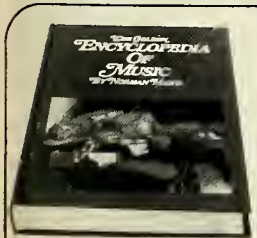
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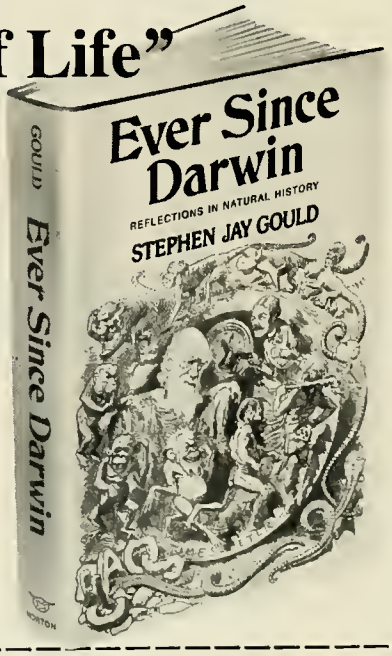
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larger or smaller sizes. Thus, prokaryotic populations not only have a diagnostic average size (point 1 above), they also have a characteristic pattern of variation about this average. The new microfossils form a beautiful bell-shaped distribution with limited spread (range from 1 to 4 micrometers). The previous, larger structures had great variation and no strong mean.

3. The new structures are "variously elongated, flattened, wrinkled, or folded" in a manner strikingly similar to Gunflint and later Precambrian prokaryotes. Such shapes are characteristic of postmortem degradation in modern prokaryotes. The larger, earlier structures were distressingly spherical; spheres, as a standard configuration of minimal surface area, can be easily produced by a host of inorganic processes—consider bubbles.

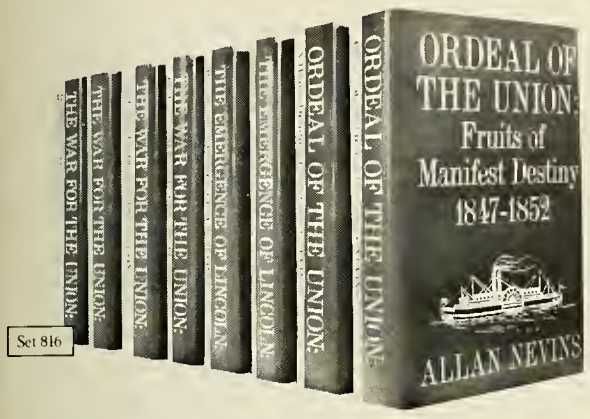
4. Most convincingly, about one quarter of the new microfossils have been found in various stages of cell division. Lest such a proportion caught *in flagrante delicto* sems unreasonably high, I point out that prokaryotes can divide every twenty minutes or so and take several minutes to complete the process. A single cell might well spend one-fourth of its life making two daughters.

5. These four arguments based on morphology are persuasive enough for me, but Knoll and Barghoorn add some biochemical evidence as well. Atoms of a single element often exist in several alternate forms of different weight. These forms, called isotopes, have the same number of protons but different numbers of neutrons. Some isotopes are radioactive and break down spontaneously to other elements; others are stable and persist unchanged throughout geologic time. Carbon has two major stable isotopes, C^{12} with 6 protons and 6 neutrons, and C^{13} with 6 protons and 7 neutrons. When organisms fix carbon in photosynthesis, they use preferentially the lighter isotope C^{12}. Hence, the C^{12}/C^{13} ratio of carbon fixed by photosynthesis is higher than the ratio in inorganic carbon (in a diamond, for example). Moreover, since both isotopes are stable, their ratio will not alter through time. The C^{12}/C^{13} ratios for Fig Tree carbon are too high for an inorganic origin; they are in the

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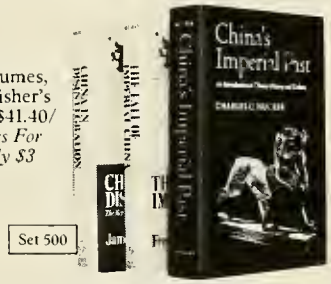


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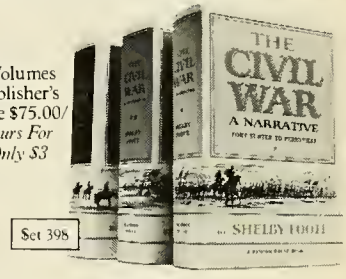
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range for fixation by photosynthesis. This, in itself, would not establish the case for life in the Fig Tree; light carbon can be fixed preferentially in other ways. But taken with the evidence of size, distribution, shape, and cellular division, this additional support from biochemistry completes a convincing case.

If prokaryotes were well established 3.4 billion years ago, how much further back shall we seek the origin of life? I have already pointed out that no suitable (or at least accessible) older rocks are known on earth, so for now we can proceed no further from the direct evidence of fossils. We turn instead to the second front-page item, the claim of Carl Woese and his associates that methanogens are not bacteria at all but may represent a new kingdom of prokaryotic life, distinct from the Monera (bacteria and blue-green algae). Their report has been widely distorted, most notably in the *New York Times* editorial of November 11, 1977. The *Times* proclaimed that the great dichotomy of plants and animals had finally been broken: "Every child learns about things being vegetable or animal—a division as universal as the partition of mammals into male and female. Yet . . . [we now have] a 'third kingdom' of life on earth, organisms that are neither animal nor vegetable, but of another category altogether." Actually, biologists abandoned "the great dichotomy" long ago. Most popular these days is a system of five kingdoms (see my column of June-July 1976): plants, animals, fungi, protists (single-celled eukaryotes, including amoebas and paramecia, with nucleus, mitochondria, and other organelles), and the prokaryotic monerans. If methanogens are promoted, they will form a sixth kingdom, joining the monerans in a superkingdom, Prokaryota. Most biologists regard the division between prokaryotes and eukaryotes, not between plants and animals, as the fundamental partition of life.

Woese's research group reported their findings in the October 1977 issue of the *Proceedings of the National Academy of Sciences*, in an article by George E. Fox and four other authors, including Woese. They isolated a common RNA from ten methanogens and from three monerans for comparison (DNA makes RNA, and RNA serves as the template upon which proteins are synthesized). A single strand of RNA, like DNA, consists of a sequence of nucleotides. Any one of four nucleotides can occupy each position, and each group of three nucleotides specifies an amino acid; proteins are built of amino acids arranged in folded chains. This, in a compressed phrase, is the "genetic code." Biochemists can now "sequence" RNA, that is, they can read the entire sequence of nucleotides in order down the RNA strand.

The prokaryotes (methanogens, bacteria, and blue-green algae) must have had a common ancestor at some time near the origin of life. Thus, all prokaryotes had the same RNA sequence at one point in their past; any current differences arose by divergence from this common ancestor. If molecular evolution proceeded at a constant rate, then the amount of difference now existing between any two forms would directly reflect the amount of time since the two had a common ancestor, that is, the last time they had the same RNA sequence. Perhaps, for example, a different nucleotide in the two forms at 10 percent of all common positions would indicate a time of divergence a billion years ago; 20 percent, two billion years, and so on.

Woese and his group measured the percent difference for all pairs of species among the ten methanogens and three monerans and used the results to construct a hypothetical evolutionary tree. This tree contains two major limbs—all the methanogens on one, all the monerans on the other. They chose three monerans to represent the greatest differences within the group—enteric (gut) bacteria versus free-living blue-green algae, for example. Nonetheless, all the monerans are more similar to each other in RNA sequence than any moneran is to any methanogen.

The simplest interpretation of these results holds that methanogens and monerans are separate evolutionary groups, with a common ancestry preceding the appearance of either. (Previously, methanogens had been classified among the bacteria.) This interpretation underlies Woese's claim that methanogens are separate from monerans and should be recognized as a sixth kingdom. Since good monerans had already evolved by Fig Tree times, 3.4 billion or more years ago, the common ancestry of methanogens and monerans must have been even earlier, thus pushing the origin of life even further back toward the beginning of the earth itself.

This simple interpretation, as Woese and his group realize, is not the only possible reading of their results. We may propose two other perfectly plausible hypotheses: 1. The three monerans that they used may not represent the entire group very well. Perhaps the RNA sequences of other monerans will differ as much from the first three as all the methanogens do. Then we would have to include the methanogens with all monerans in a single grand group. And 2. The assumption of nearly constant evolutionary rates may not hold. Perhaps the methanogens split off from one branch of monerans long after the main groups of monerans had branched from their common ancestor. These early methanogens may have evolved at a faster rate than the moneran groups diverged from each other. In this case, the great difference in RNA sequence between any methanogen and any moneran would record a rapid evolutionary rate for early methanogens, not a common ancestry with monerans before the monerans themselves split into subgroups. The gross amount of biochemical difference reflects the time of divergence only if evolution proceeds at reasonably constant biochemical rates.

But one other observation makes Woese's hypothesis very attractive and inspires my own strong rooting for it. The methanogens are anaerobic; they die in the presence of oxygen. Hence, they are confined today to unusual environments: muds at the bottom of ponds depleted of oxygen or deep hot springs in Yellowstone Park, for example. (The methanogens grow by oxidizing hydrogen and reducing carbon dioxide to methane—hence their name.) Now, amidst all the disagreement that afflicts the study of our early earth and its atmosphere, one point has gained general assent: our original atmosphere was devoid of oxygen and

On Photographing the Invisible

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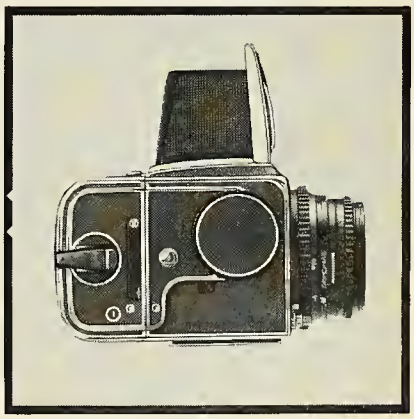
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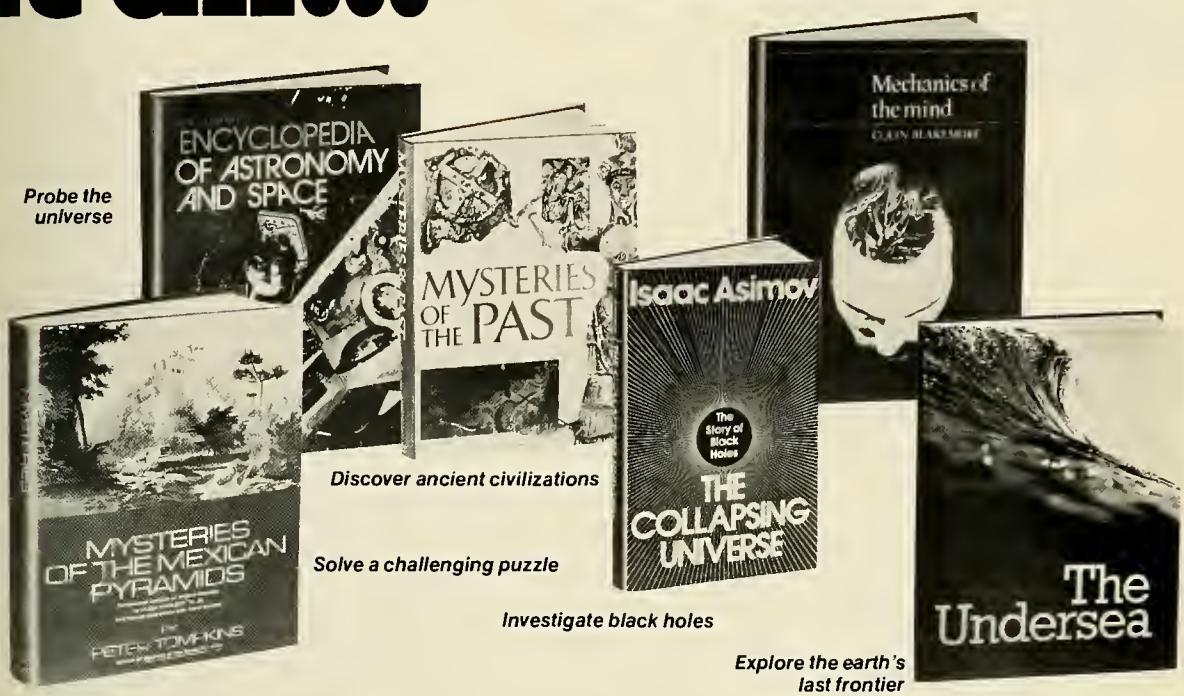
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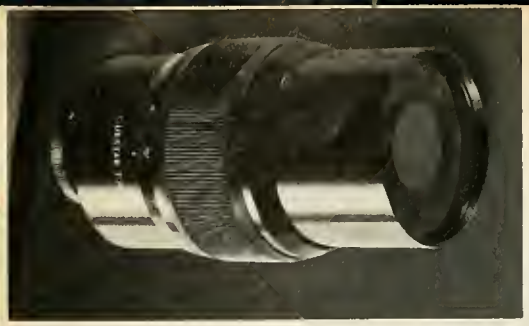
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Henry E. Gardiner



rich in carbon dioxide, the very conditions under which methanogens thrive and for which the earth's original life might have evolved. Could modern methanogens be the remnant of the earth's first biota, originally evolved to match its general condition, but now restricted by the spread of oxygen to a few marginal environments? We believe that most free oxygen in our atmosphere is the product of organic photosynthesis. The Fig Tree organisms were already indulging in photosynthesis. Thus, the golden age of methanogens may have passed long before the advent of Fig Tree monerans. If this reverie be confirmed, then life must have originated long before Fig Tree times.

In short, we now have direct evidence of life in the oldest rocks that could contain it. And, by reasonably strong inference, we have reason to believe that a major radiation of methanogens predated these photosynthesizing monerans. Life apparently arose about as soon as the earth became cool enough to support it.

I exceeded my assigned column length long ago, but I cannot leave this topic without two closing thoughts, admittedly reflecting my own prejudices. First, as a strong adherent to exobiology, that great subject without a subject matter (only theology may exceed us in this), I am delighted by the thought that life may be more intrinsic to planets of our size, position, and composition than we had ever dared to imagine. I feel even more certain that we are not alone, and I hope that more effort will be directed toward the search for other civilizations by radio-telescope. The difficulties are legion, but a positive result would be the most stupendous discovery in history.

Secondly, I am led to wonder why the old, discredited orthodoxy of gradual origin ever gained such strong and general assent. Why did it seem so reasonable? Certainly not because any direct evidence supported it.

I am, as regular readers of this column know to the point of tedium, an advocate of the position that science is not an objective, truth-directed machine, but a quintessentially human activity, affected by human passions, hopes, and cultural biases. Cultural traditions of thought strongly influence scientific theories, often directing lines of speculation, especially (as in this case) when virtually no data exist to constrain both imagination and cultural prejudice. In my own work, I have been impressed by the powerful and pernicious influence that gradualism has exerted on paleontology via the old motto *natura non facit saltum* ("nature does not make leaps"). Gradualism, the idea that all change must be smooth, slow, and steady, was never read from the rocks. It was primarily a prejudice of nineteenth-century liberalism facing a world in revolution. But it continues to color our supposedly objective reading of life's history.

In the light of gradualistic presuppositions, what other interpretation could have been placed upon the origin of life? It is an enormous step from the constituents of our original atmosphere to a DNA molecule. Therefore, the transition must have progressed laboriously through multitudes of intervening steps, one at a time, over billions of years.

The history of life, as I read it, is a series of long stable states, punctuated at rare intervals by major events that occur with great rapidity and set up the next stable era. Prokaryotes ruled the earth for 3 billion years until the Cambrian explosion, when all the major designs of multicellular life appeared within 10 million years. Some 375 million years later, about half the families of invertebrates became extinct within a few million years. My favored metaphor is a world of occasional pulses, driving recalcitrant systems from one stable state to the next.

Physicists tell us that the elements may have formed during the first few minutes of the big bang; billions of years since have only reshuffled the products of this cataclysmic creation. Life did not arise with such speed, but I suspect that it originated in a tiny fraction of its subsequent duration. But the reshuffling and subsequent evolution of DNA have not simply recycled the original products; they have produced wonders.

Biologist Stephen Jay Gould's most recent book is Ever Since Darwin: Reflections in Natural History.

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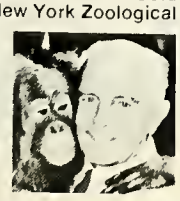
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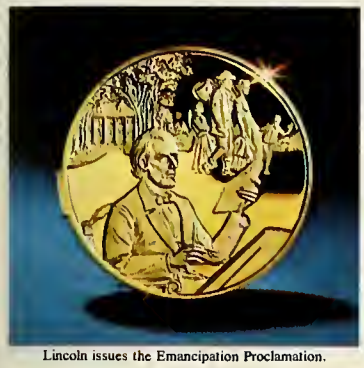
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Jefferson signs Louisiana Purchase treaty.



Lincoln issues the Emancipation Proclamation.

seizure of the steel mills? The medallic history reflects the choices Gerald Ford made. In doing so, he used many criteria. But one was of overriding importance: "I tried to identify the events that would be most meaningful to the *American people* themselves," he explains.

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John F. Kennedy orders blockade of Cuba.

finalized, that Gerald R. Ford summed up his concept of this unique historical project. "Having known and worked with five Presidents, and having served as President myself, I have come to know the many facets of this office. So this history, of course, reflects my view. But in a larger sense, it belongs to the American people. And if this manner of dramatizing history results in a better understanding of our heritage of freedom, it will have been a most worthwhile project."



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by Stephen P. Maran

Strung-Out Stars

The presence in the Milky Way of loose associations of young stars indicates that such groups are still forming in our galaxy

A unique class of star clusters known as OB associations, which was first recognized thirty years ago, has been the subject of much recent telescopic investigation and theoretical analysis. Despite alternate theories, it appears that an OB association consists of young, massive stars that may have been formed as a consequence of a sequence of explosions of even more massive and shorter-lived stars.

The characteristics that distinguish an OB association from other kinds of star clusters include its size, the kind of stars found within it, the loose arrangement of those stars, and the association's tendency to expand. Association stars are spaced much farther apart than those of a globular cluster (*see* "Stars by the Cluster," *Natural History*, October 1976) or even those of the less densely packed "open" clusters, such as the familiar Pleiades. In addition, nearly all the stars observed in OB associations are massive, young, blue types known as O and B (hence the name "OB association"). Many of these stars are less than ten million years old. Stars in other kinds of clusters are generally older, cooler, and less massive.

In 1947, a leading Soviet astronomer named Victor Ambartsumian suggested that the many OB associations observed in our galaxy, the Milky Way, represent clear evidence for the continuing formation of large numbers of stars in the galaxy. Thus, according to Ambartsumian, extensive star formation did not cease when the Milky Way itself was formed. Other astronomers had reached the same conclusion from their own points of view, but Ambartsumian's argument was novel.

In simple terms, Ambartsumian's reasoning can be restated as follows: The stars of the Milky Way follow orbits around the center of the galaxy. An OB association is large enough (some exceed 300 light-years in diameter) to cause the stars on the inner side of the group, that is, the side closer to the galactic center, to orbit at noticeably faster rates than those on the outer side. They will therefore draw ahead, like the lead race cars in the Indianapolis "500," and the whole pack will gradually be stretched out by this process of "differential galactic rotation" until it is no longer recognizable as a distinct star cluster. This stretch-out will occur in a very short time span compared with the age of the galaxy (about fifteen billion years). The fact that OB associations can be observed in the Milky Way as discrete objects tells us accordingly that they are of recent vintage. This conclusion also provides independent confirmation of the deduction from the accepted theory of stellar evolution that O and B stars are much younger than the average stars in our galaxy. Ordinary star clusters are not drawn apart by differential galactic rotation because their internal gravitational attraction, which draws the member stars toward the cluster center, is strong enough to prevent their disruption. Hence, the ordinary cluster revolves around the galactic center as a unit.

In 1952, a Dutch astronomer at the Leiden Observatory verified a suggestion by Ambartsumian that another, more striking process might act to disrupt OB associations, namely, that the member stars of an association are actually flying away from each other. In the terminology of astrophysics, associations are "stellar systems of positive total energy." Ordinary star clusters have negative total energy, meaning that their internal gravitational force is sufficient to prevent the clusters from dissipating into galactic space. For this reason, ordinary globular and open clusters are not expanding. In an association, however, the opposite is true, and thus it seems that an association would break up even in the absence of differential galactic rotation. In fact, it has been suggested that the expansion of an association is what makes it large enough for differential galactic rotation to become a significant disruptive factor.

Further studies have shown that a typical OB association is not a single group but consists of several loose clumps, or "subgroups," of stars, each gradually spreading out in the same way that the association as a whole is expanding.

Ambartsumian proposed that the hundreds of stars in a typical large association were formed from the disruption of a single, very dense "prestellar body." He admitted, however, that there was no evidence for the existence of such objects in the undisrupted state nor any explanation for how such a body might fragment into normal stars. An explanation for the origin of OB associations was therefore required. Such a theory should account for their stellar composition, size, subgroup structure, and tendency to expand. It should also account for their continued formation during the last few hundred million years.

In October 1953, Ernst J. Öpik, an Estonian astrophysicist at the Armagh Observatory in Northern Ireland, lectured on "The Death



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and Birth of Stars," at the Armagh Centre of the Irish Astronomical Society. In this talk, later amplified in an article, he proposed that OB associations form when a rapidly expanding shell of gas is ejected by a supernova explosion such as the one that produced the Crab Nebula. The shell rushes into the thin gas of interstellar space, piling it up in the process just as snow is swept up by the blade of a snowplow. In the thus-thickened interstellar gas, new stars would condense by a means that could not be specified but was inferred to occur. The new stars would make up an OB association, which would expand outward from its center because the member stars were formed from gas driven outward by the supernova shell. Öpik also speculated that some of the stars created in this way would themselves eventually become supernovae and might subsequently give rise to future OB associations by the same process.

The Öpik theory was most imaginative but it lacked a vital link, namely, a clearly defined process of star condensation. Accordingly, it is not too surprising that the theory apparently attracted scant attention and was nearly forgotten for two decades.

In 1974, a specialist in galactic studies at the Max Planck Institute for Radio Astronomy in Bonn, West Germany, published the results of a comprehensive investigation of an expanding supernova shell on the boundary of the constellations Orion and Gemini. The author named the shell the Origem Loop and concluded that it was one of the oldest and largest supernova remnants yet discovered. Perhaps her most significant finding, however, was that superimposed on the Loop, as seen from the earth, are five nebulae of the type that are heated and made to glow by the internal presence of O and B stars such as those in OB associations. The methods used to estimate the distance of such nebulae from the earth indicated that they were at the same distance as the Loop and therefore might actually coincide with it. Apparently, the stars of these five nebulae, which make up a small OB association, had formed in response to an effect of the expanding supernova shell on the interstellar gas clouds in its

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vicinity, as predicted by the Öpik theory.

The aforementioned article did not refer to Öpik's work; indeed, the author may have been unaware of it. However, the article caught the eye of a Turkish colleague of mine, Hakki B. Ögelman, who was on a year's visit to this country from the Middle East Technical University in Ankara. In August 1975, inspired by the apparent discovery of star formation in the Origem Loop, he and I drafted an updated version of Öpik's theory on the origin of OB associations.

Many advances in astrophysical understanding since 1953 contributed to our formulation of the revised theory. The most important of these was the general recognition (as a result of detailed calculations made independently by several astronomers) that shock waves, including the kind of blast that travels out into space from a supernova explosion, can cause an interstellar gas cloud to begin condensing into stars. The calculations show that when a shock wave encounters an interstellar cloud, it will race around the exterior of the cloud more rapidly than it can penetrate to its center. As a result, the cloud, instead of simply being blasted from one side, is effectively squeezed from all directions. A similar effect is reported to demolish buildings subjected to the blast wave from nuclear bomb tests: they are blown *together*, rather than *apart*. The compression of an interstellar cloud by the supernova shock wave causes the cloud to condense and break up into stars, and this may be the missing process that the Öpik theory required.

There has been much progress recently in the study of how stars evolve, and the results of this work also have important applications to the theory of how OB associations are formed. In particular, it is well established that when stars begin to condense, the more massive ones form most rapidly. Further, when the stars are formed and nuclear reactions begin under conditions of high pressure and temperature at the stellar centers, the most massive stars, that is, those of types O and B, which have the largest internal nuclear "furnaces," burn most rapidly. As a result, these massive stars may exhaust their fuel while smaller stars in the same

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association continue to burn slowly or, in some cases, are still in the formative stage. When the massive stars reach the end of their fuel, the accepted stellar evolution theory predicts that they will go out in a blaze of glory in a supernova explosion.

In our version of the association-formation theory, my colleague and I proposed that the shock wave from an initial supernova explosion triggers the formation of an association subgroup. Among the newborn stars of the subgroup, the most massive ones evolve most rapidly for the reason explained above. Thus, the two or three most massive stars of the subgroup will reach the end of their lives and themselves become supernovae, while the smaller stars are still comfortably husbanding their modest internal fuel supplies or are only in the process of forming. The two or three second-generation supernovae created in this way will each generate a shock wave that, in turn, causes additional new stars to form. Each supernova thereby produces a new subgroup. In each subgroup, once again the most massive stars will soon become supernovae themselves.

An OB association is thus produced by a chain reaction of stellar explosions, which we have termed the "supernova cascade." By taking into account the estimated time intervals required for each step in the process and the radius of expansion of a supernova shock wave during each relevant interval, we found that this cascade might well explain the observed characteristics of OB associations, including their expansion, subgroup structure, and size.

Further evidence for supernova-induced star formation comes from observations of a group of stars and associated nebulosity known as CMa R1 that appears to be even younger than most OB associations. According to a recent study by two astronomers at the Carnegie Institution of Washington, CMa-R1 is located on the edge of a supernova remnant dating from a stellar explosion that occurred about 500,000 years ago. The Carnegie astronomers suggested that a nearby OB association may have been the site of the supernova that gave rise to CMa R1. They have also revived a suggestion made by Öpik that the Barnard Loop, a large nebula of uncertain nature in Orion, is a supernova remnant related to the prominent OB association observed within it. Similar findings have been reported for several other associations as well.

In short, there appears to be increasing evidence that supernova shock waves may have given rise to stellar associations. However, the Milky Way has other kinds of shock waves that might produce the same effects. In particular, there is a shock wave associated with the spiral pattern of our galaxy and there may be shock waves generated by the formation of electrically excited, or ionized, nebulae around young, hot stars. These kinds of shock waves have been proposed as the mechanism that creates OB associations. It seems likely to me that both of them, as well as the supernova cascade, may contribute to star formation in the Milky Way.

Stephen P. Maran is senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

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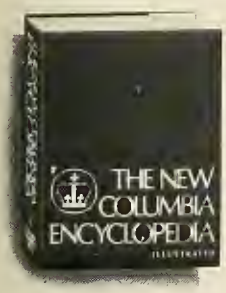
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Chickpeas, like other legumes, are a good source of cheap protein

If that noblest Roman prose writer of them all, Marcus Tullius Cicero, were alive today, his favorite New York restaurant would probably be Max's Kansas City, the once hip, slightly faded saloon near Union Square. Cicero would not be attracted to Max's out of some feeling for this former haunt of Andy Warhol's "superstars." But he would like the sign out front, which promises "steak, lobster, chickpeas." The hero of the Catilinarian orations would actually be drawn, not to the steak and lobster, but to the chickpeas, and for a special reason. Cicero's family name is a form of the Latin word for chickpea, *cicer*. Leguminous cognomens were not unusual in ancient Rome. With no apparent loss of dignity, eminent folk went about the imperial city identifying themselves as Lentil (Lentulus) and Pea (Piso).

Strictly speaking, legumes (order Leguminosae) are no laughing matter today either. Peas, beans, peanuts, soybeans, and chickpeas are the outstanding nonmeat source of protein in nature. But the chickpea, which flourishes in dry, warm climates (the Mediterranean littoral, the Near East, and India), is, at best, a marginal item in our North Temperate Zone diet. And its name (Cicero notwithstanding) makes it sound funny. Only in Spain, as *garbanzos*, do the seeds of *Cicer arietinum* escape the curse of nomenclatural comedy. In France, they are *pois chiches*, a compound derived from the Latin word for pea and from *cicer*. But *chiche* is vernacular French for "I dare you."

Germans, who rarely eat chickpeas, must refer to them as *Kichererbsen*, a pairing of *kicher* (from *cicer*) and the garden-variety, German word for peas, *Erbsen*. Unfortunately, there is an etymologically unrelated verb, *kichern*, which means high-pitched laughter. To German ears, then, *Kichererbsen* are gigglepeas. In Italy, tasty, flat-sided, beige *ceci* are popular, boiled whole in soup or ground into flour. And yet, they are also the source of a decadent, seventeenth-century word, *cicisbeo*, an inversion of *bel cece*, beautiful chickpea, which was the name given to men who appeared in public with other men's wives. *Cicisbeos* were socially approved escorts in a culture where no chic woman would go out with her own husband as her escort.

Chickpeas go back much, much further in history. They crop up in Egyptian hieroglyphic texts as the "hawk face." The name comes from the beaklike projection that grows on one side of the seeds. This small protuberance made later observers think of a ram's head, whence the species name, *arietinum*, from *aries*, Latin for ram. Less fanciful observers see a typical legume, a pealike, bushy, hairy plant that grows two feet high and fruits in the form of pods. The flowers emerge from the bud in three tiers of petals. The top petal is the "banner"; two lateral petals are called wings; a lower pair, sometimes united, enclose stamen and pistil and are known as the keel.

Planted eight to twelve inches apart, chickpea plants produce white or reddish flowers and yield anywhere from 500 to 1,000 pounds of seeds per acre. The sparse foliage is poisonous and cannot be used for forage, but the green pods are edible and are sometimes used as an adulterant or substitute for coffee. The seeds are, of course, the point of the exercise. Highly nutritious—good sources of cheap protein, carbohydrates, fats, and B vitamins—chickpea seeds are so valued in India that they are raised on a vast acreage estimated to equal the entire worldwide acreage devoted to sugar cane.

This leguminous bounty is, substantially, the result of a beneficial infection. Chickpeas, like other legumes, have characteristic nodules on their roots. These swollen tubercles are the visible aspect of a symbiosis between legume root cells and certain bacteria of the genus *Rhizobium* that are capable of processing, or "fixing," free nitrogen out of the air and passing it on to the host plant. Nitrogen is, of course, the principal component of artificial fertilizers and it is a vital element of proteins. Properly inoculated legumes thus can, and do, fertilize themselves.

This is why legumes are so high in protein. And it also explains why legumes have been rotated with other crops since ancient times. Plowing under unwanted parts or all of a legume cover crop—a method known as green manuring—dates from at least as far back as Vergil and Theophrastus, who described it. Today, with fertilizer prices zooming, scientists are exploring the possibility of developing a similar nitrogen-fixing capability in nonleguminous crops. Meanwhile, an unrelated plant-growth stimulant has apparently been dis-

covered in that common legume alfalfa.

In addition to their undoubted nutritional and chemical value, legumes are worth having around because they taste good. The diversity of the family's edible parts is quite surprising. Consider only that we benefit at table from peas, soybean curd (tofu), and lentils; from wax beans, broad beans, green beans, limas, and mung bean sprouts. Some legume seeds are sold dried; some come to us green and tender. Some plants, like the ordinary green bean, are cultivated for their pods. The Chinese manufacture a bewildering spectrum of bean-paste condiments. Mexicans produce their own, hot-blooded bean dip.

Perhaps we take this relatively mundane array too much for granted. We should certainly not dismiss the pea and the bean as plain fare. Fresh from the garden and boiled in generous amounts of salted water (a rapid, taste-preserving, and nutritious method of preparation), they will emerge bright green and riotous with flavor, a treat for any palate, no matter how sophisticated.

Still, most legumes are household words, and need little introduction. *Cicer arietinum*, on the other hand, is a relatively unknown quantity, which most of us rarely use except straight from the can as an oddment in salads. Unprocessed chickpeas are available in specialty markets and health food stores. They are very hard and should be soaked overnight. Some authorities start with lukewarm water and add salt and a little flour. This seems unnecessary, as does the canonical addition of a pinch of bicarbonate

by Raymond Sokolov

Fertilizing: Its importance in creating superior wines.



Fertilizing the vineyard is a vital part in the art of growing premium wine grapes. It is not a simple operation.

Its Importance

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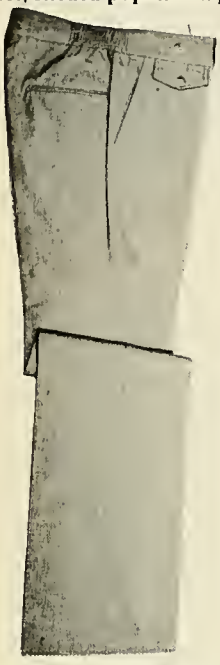
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of soda the next day before you begin boiling them (except where water is hard). It is normally sufficient merely to drain the soaked chickpeas, put them in fresh water to cover, and simmer, covered, for an hour or until tender. Then drain again, submerge in cold water, and rub until the skins separate from the seeds. The skins will float to the surface of the water and can be skimmed away. At this point, you are ready to prepare a whole range of unusual and hearty recipes. Indeed, an entire meal can be prepared with chickpeas, from hors d'oeuvres to dessert. I do not propose this as something anyone would actually wish to try, only as proof of the ingenuity of the human mind and evidence of the versatility of an underused foodstuff.

The best known chickpea appetizer is the Near Eastern specialty *hummus*. This is a paste concocted from sesame seed oil (sold as tahini in Arab and specialty markets) and mashed, cooked chickpeas flavored with lemon juice and garlic. In Italy, puréed chickpeas go into a soup with pasta and other flavorings, for example, tomato and anchovy. In the Caucasus, whole cooked chickpeas garnish a chicken soup enriched with rice, prunes, and dill. In southern France, you may run into a cold hors d'oeuvre of chickpeas simmered in white wine with thyme and garlic.

For the most part, however, chickpeas come in side dishes or as an element of complex main dishes. Israelis mix them with fava beans in a doubly leguminous salad. In the Caucasus, there is a dish called *siserov shanakh*, spinach steamed with a little tomato paste and garnished with chickpeas. The same region makes wheat pilaf with liver and chickpeas.

North Africans use chickpeas frequently in some kinds of couscous. The most exotic version is Tunisian and employs such spices as ground dried rosebuds, as well as quince and fish.

Sausages and chickpeas in broth have entered the French repertory as *pois chiches à la catalane*, because the original version of the dish evolved south of the Pyrenees near Barcelona, the capital of Spanish Catalonia. Innumerable chickpea side dishes involve simmering onions with typical local spices, then adding chickpeas and heating them through. Spicy, cumin-laden Indian chickpeas or chili-powered chickpeas from New Mexico are examples of this basic theme and variations.

Chickpea flour, available in speciality outlets and in Indian markets (where it is called *besan*), is a staple of the Mediterranean and India. I have seen two versions of the deep-fried "French fries" called *panisetti* on the Ligurian coast of Italy and *panisses* in neighboring Nice. There are minor differences. Basically, though, deep-frying small strips of moistened and boiled chickpea flour produces a crisp, starchy finger food with greater personality than potatoes can offer. Chickpea flour can also be used for dessert. *Mysore pak* is the name of the Indian pastry that will round out our imaginary, all-chickpea meal. Ghee, almond flavoring, sugar, and cardamom are combined with *besan* to make a sweet, flat, high-protein cake. Gigglepea indeed!

Panisetti
(Chickpea French fries)

Salt
I cup chickpea flour
3 tablespoons olive oil
Oil for deep frying

1. Bring 1½ cups of salted water to a boil. Stir in the chickpea flour. Stir until smooth.
2. Place over an asbestos pad and continue cooking for at least an hour over lowest possible heat, stirring frequently. (One recipe calls for 3 hours and achieves a very nutty flavor.)
3. Push the cooked flour through a sieve into a mixing bowl. Stir in the 3 tablespoons olive oil.
4. Spread this dough on an oiled surface such as a plate, using a knife and cleaning it as necessary in hot water to remove adhering dough. (Dough should be about ½ inch thick.)
5. Let cool. Cut in strips of any length. Deep fry a few at a time in smoking oil until crisp and brown. Drain on paper towel and keep warm until the entire batch is fried.

Yield: 4 to 6 servings.

Raymond Sokolov is a free-lance writer whose special field of interest is the history and preparation of food.

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by Arthur W. Galston

A Living Fossil

One small plant has a long history and tells a complicated story that is still unfolding

Imagine the emotions of a paleontologist, long a student of dinosaur evolution, who suddenly encountered a live *Brontosaurus*, *Triceratops*, or *Tyrannosaurus*. That is roughly what happened about ten years ago to Sanford Siegel, a University of Hawaii botanist, when he examined the microorganisms of a sample of soil he had gathered near the wall of Harlech Castle in Wales. When he cultured that soil sample in the presence of concentrated ammonium hydroxide, which greatly inhibits or arrests the life processes of most conventional cells, the medium triggered the growth of microscopic clusters of star-shaped bodies attached to slender stalks. Each body, about 5 micrometers (0.0002 inch) in diameter, closely resembled pictures Siegel had seen of a recently discovered fossil microorganism. But as far as he knew, no living specimens of this organism had ever been described. With the help of the fossil's discoverer, Elso Barghoorn of Harvard University, Siegel was able to establish, in a strange sequence of paleobotanical events, that he had found a living relative of an organism first described as a fossil.

Barghoorn had made his own discovery while gathering specimens of ancient rocks in a search for primitive organisms. One specimen of chert, or flintlike rock, from Kakabek in Ontario, Canada, contained peculiar umbrellalike forms that seemed regular enough in physical appearance and structure to be considered microorganisms, rather than a pattern that had developed as the rock formed. Barghoorn named these microorganisms *Kakabekia umbrellata*, meaning umbrellalike form from Kakabek.

Since the rocks in which Barghoorn's forms appeared dated from the middle Precambrian period, about two billion years ago, the microorganisms were among the oldest of all plantlike fossils. Siegel's discovery of a living relative of Barghoorn's fossils established a remarkable thread of biological history. Siegel named his creature *Kakabekia barghoorniana* in honor of his colleague.

Siegel had come to Harlech Castle in the course of a long project. For many years, with the support of the National Aeronautics and Space Administration, he had been examining the physiology of organisms under stress, especially stress caused by harsh environments likely to be encountered during space travel or near or on other planets. Because ammonia is generally thought to have been one of the more abundant components of the primitive earth's atmosphere, and is still one of the major components of the present atmosphere of Jupiter, Siegel wanted to study earthly environments with abundant ammonia. Natural candidates for examination were soils saturated with urine. On a chance visit to Harlech Castle, he observed tourists urinating near the castle walls, and learning that this was an old practice, decided to collect his first soil sample. Since the organism he discovered in that soil thrived in the presence of concentrated ammonium hydroxide and was not seen in other environments, Siegel hypothesized that he had found an obligate ammonophile, an organism that requires ammonia in order to grow.

In the ten years since he first visited Harlech Castle, Siegel has found that he was mistaken about *Kakabekia*'s need for ammonia. At sea level, the microorganism does require the compound, yet *Kakabekia* also appears in certain mountainous regions low in ammonia but high in alkalinity. Without ammonia, *Kakabekia* needs special soil conditions, as well as peculiar combinations of temperature and altitude, to thrive.

In soil samples from Hawaii, California, the Great Plains states, Illinois, New York, western Europe, and northern South America, Siegel found no signs of *Kakabekia*. But the microorganism did show up in soils from Alaska, Iceland, and various alpine regions. So temperature seemed to be one of the factors governing the distribution of modern *Kakabekia*. But in studying its distribution up Hawaiian and Japanese mountain peaks, Siegel found that it grew in bands, which meant that at least one other factor was interacting with temperature to limit the organism's distribution. At

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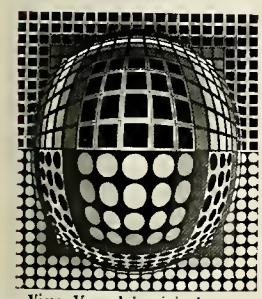
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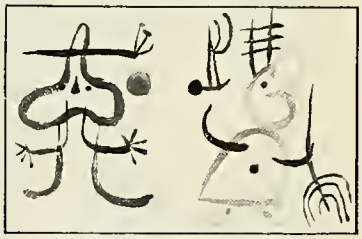


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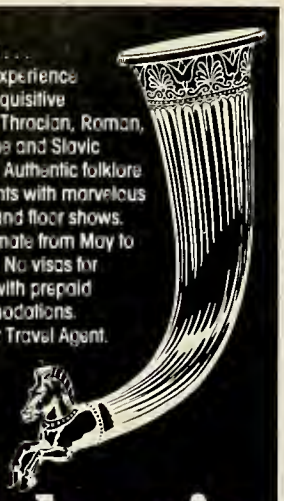
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lower elevations, *Kakabekia* is not found below about 45° north latitude, and thus appears restricted to regions with comparatively cool summers. At latitudes closer to the equator, it grows only at altitudes above 6,500 feet. Since air temperature decreases about 7°C (about 12°F) for each 3,300 feet of altitude, *Kakabekia* seemed to require low temperature and a certain altitude.

The *Kakabekia* Siegel found on Mauna Kea, an extinct volcano in Hawaii, appeared to bear out his ideas about the microorganism's temperature and altitude requirements. He recovered it on the volcano at altitudes above 11,500 feet. Once cultured, organisms consistently appeared in his soil samples at −7°C, but not at 30°C. But at about 10,000 feet up Mauna Kea, and on down to the base of the mountain (about 7,500 feet above sea level), *Kakabekia* showed exactly opposite characteristics, growing at 30°C, but not at −7°C. This second *Kakabekia*, which has adjusted ecologically to warm temperatures, seems to be a variant of the cryophilic, or low-temperature-favoring, strain that Siegel had found earlier.

There are other variants of *Kakabekia*, with differences in the umbrellalike cap, with or without a stipe, or stalk. The umbrella may be lobed, scalloped, fringed, or cut into rather acute angles, and may have varying numbers of rays, the umbrella's ribs. These strains probably represent genetic variants that evolved from some prototypical form.

Another peculiarity of *Kakabekia* is that its cultures require no oxygen, but unlike typical anaerobic bacteria such as *Clostridium*, which causes gangrene, it is not killed by oxygen in the air. *Kakabekia* does require a distinctly alkaline environment, which can be furnished equally well by sodium hydroxide, potassium hydroxide, or ammonium hydroxide at a level that would be toxic to most living creatures. When sodium hydroxide is replaced by sodium metasilicate, which provides the same kind of alkaline environment, as well as silica, *Kakabekia* grows more slowly, or stops altogether. Since it contains large quantities of silica (the hard part of its cell walls that leaves a fossil) and has almost always been found with diatoms (algae that have silica cell walls), researchers thought that *Kakabekia* could easily take advantage of silicon in its microenvironment. But if metasilicate is toxic to *Kakabekia*, it must obtain its silicon from ordinary minerals in soil, possibly from sand, which is silicon dioxide.

So far we know little about the *Kakabekia* cell and its metabolism. Our information has been limited because we have been unable to grow *Kakabekia* in pure culture—all cultures have been contaminated by other organisms, invariably diatoms—and because *Kakabekia* cells seem to grow very slowly. We do know that when these cells are tested with the Feulgen stain, which shows up the DNA of chromosomes, the results are negative. Since all known living things must contain DNA, *Kakabekia* is probably a prokaryote, an organism that, like a bacterium, does not have its chromosomes gathered into a discrete nucleus. This hypothesis is supported by the discovery by several Russian workers of some star-shaped bacteria that develop in certain kinds of soil or in creek water rich in organic material. Although *Kakabekia* is nearly twice as large as these bacteria, they do have a marked morphological resemblance. Their possible genetic relation is seconded by the fact that all of the star-shaped bacteria have been collected from cool regions.

Kakabekia's slow growth raises questions in itself. In order to grow, it must have oxidizing enzymes that will mobilize energy from its environment. Yet preliminary experiments have revealed that *Kakabekia* contains neither the deme enzyme nor the phenol-oxidizing enzymes that are most organisms' conventional means of producing energy.

At present, researchers' questions about *Kakabekia* far outnumber the answers. Siegel and other workers will be looking for the microorganism for some time in such scattered places as Point Barrow, Alaska; Surtsey Island off Iceland; the top of Mauna Kea in Hawaii; and Harlech Castle in Wales. When all of the living fossil's long history is clear, microbiologists and evolutionists will have new stories of their own to tell us.

Arthur W. Galston teaches biology at Yale University.

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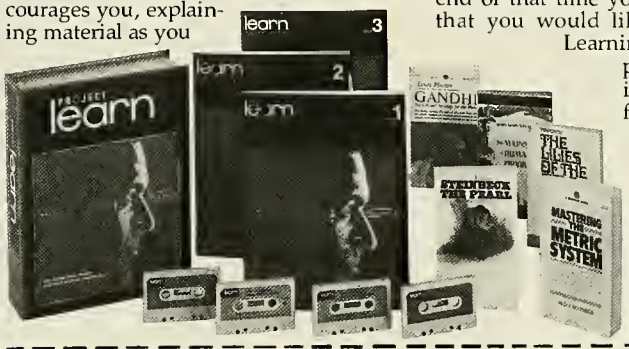
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Abundant Birds of Beringia

by William H. Drury
photographs by Hope Alexander

While population diversity is usually limited in the higher latitudes, geologic forces and biological productivity in the Bering Sea region have created an oasis for avian fauna

Most people who take an introductory college biology course learn of several geographic rules that account for both the diversity of species within an area and the population size of these species. One of these rules is that tropical regions produce many species, but that populations of each species are small. A bird watcher in the inland tundra of Alaska would be lucky to spot twenty bird species in a day, but in the forests, fields, and swamps of Central America, the sighting of two hundred species in a day is not unusual.

Another rule states that while fewer species inhabit the higher latitudes, their populations tend to be large. Antarctica, its coastal islands, and islands in the South Atlantic, for example, have huge populations of penguins, petrels, and other marine birds.

The difference in species diversity and population size in the two areas is essentially a reflection of climate and biological productivity: uniformly warm and moist climates support more species than do climates in which temperature or rainfall varies widely.

Most rules are made to be broken. Although many species, particularly land animals, conform to these geographic rules, some do not. Exceptions occur among marine species that thrive on the vast food resources made available by cold water, currents, and upwelling systems. One of the most pronounced exceptions are the sea birds, waterfowl, and shore birds of the Bering Sea between Alaska and Siberia. Vast populations of more than thirty-four species nest on its many islands and along its ragged coastline. On the Pribilof Islands in the southern Bering Sea, some 225,000 red-legged kittiwakes—nearly the entire world population—nest along with roughly 100,000 black-legged kittiwakes, 1.5 million thick-billed murres, and enormous numbers of crested and least auklets. Six hundred miles to the north, one million least auklets crowd the cliffs and rock-strewn shores of Little Diomede Island in the Bering Strait.

Each spring the number of species in the Bering Sea increases as those that have spent the winter at sea around the Aleutian Islands or along coasts of the Pacific Ocean in both North and South America return to their nesting areas. During May, murres, kittiwakes, and puffins appear by the thousands in the widening leads among the ice flows or gather in the open water beneath nesting cliffs. Great flocks of eiders and old squaws and scoters hurry north along the windrows of drift ice. By late May, auklets swarm like mosquitoes around the rubble slopes of the islands.

Later in the summer, short-tailed shearwaters from the Southern Hemisphere arrive through the passes of the Aleutian Islands and cross over the waters of the continental shelf near Saint Lawrence Island on their way to the Bering Strait and the Chukchi Sea. During the last century, short-tailed albatrosses skimmed the northwest Bering Sea at this time of year. Today, few are seen because during the late nineteenth and early twentieth centuries, plume hunters nearly exterminated the great birds on their breeding islands off Japan.

With a few conspicuous exceptions, such as the sooty tern of tropical seas or the quelea weaver finch of the East African plains, high bird populations are rare in the tropics both north and south of the equator. The number of sea bird species in more equatorial oceanic systems is also far lower than in the Bering Sea. Only some twenty or so endemic species inhabit either the Hawaiian Islands or the Galápagos Archipelago to the south. About the same number inhabit the coast of southern California.

Marine bird species do not live in great profusion everywhere in the Bering Sea. Rather, they crowd into definite centers. One of these is at the western end of the curving line formed by the Aleutians and the Commander Islands, extending from southwestern Alaska west to the Kamchatka Peninsula, which dangles off eastern Siberia. Murres, guillemots, puffins, and kittiwakes nest in extensive colonies along this chain. In addition, four species of auklet occur here. One, the whiskered auklet, is restricted in its

Kittiwakes and murres often nest on the same cliffs. The murres choose ledges closer to the summits and lay eggs on the bare rocks, whereas kittiwakes make nests.



nesting to the Aleutians and neighboring Siberian islands.

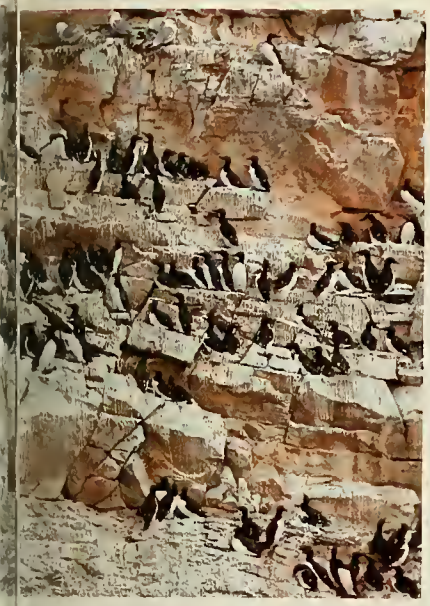
The Pribilof Islands are another major population center. Still another center of species diversity is in the Bering Strait and the Chirikof Basin, the northernmost part of the Bering Sea just south of where Siberia and Alaska stand nose to nose. Three species of auklet—least, crested, and parakeet—nest in large colonies on Saint Lawrence, King, and Little Diomede islands. Birds are not the only animals that show great species diversity in the Bering Sea. Forty-five species of sculpin—large-headed, spiny fish—dwell in the deep southern part of the Bering Sea and along the edge of the continental shelf, and five species of salmon ascend Alaska's rivers each spring to spawn. In contrast, only one salmon species inhabits the North Atlantic.

The terrestrial flora of the region is also varied, far more so than in the higher latitudes of interior North America. The flora of the entire Canadian Arctic archipelago numbers 340 species. On Alaska's Seward Peninsula alone, botanists have recorded 475 species of vascular plants.

Widely different climatic conditions within Beringia—the area that includes Alaska's interior mountains, its southeast coastal ranges, the Aleutian-Commander Islands chain, the Kamchatka Peninsula, and the Bering Strait islands—account, in part, for the region's intriguing and complex faunal and floral diversity. This climatic











Murres, top left, crowd together in tightly packed colonies, but kittiwakes, left, space their nests on long, narrow ledges and defend an area about six inches wide on each side. Because murres do not build nests, egg loss is higher than among kittiwakes. Potential loss is lessened because the egg's shape–wide at one end, narrow at the other–prevents it from easily rolling off. Pacific cormorants, above, nest on shorter, wider ledges, often at the edge of kittiwake and murre colonies.

variety is, in turn, caused by pronounced topographic relief, which also creates various habitats. The climate of the Aleutian Islands and southeastern Alaska, for example, is mild and moist, whereas that of the Seward Peninsula is bitterly cold and surprisingly dry. In interior Alaska, the temperature on winter days might be −50°F, while in summer, the heat is worse than Miami's.

Geologic forces have also contributed to large populations and diversity of sea birds. Much of the



High sea bird populations do not occur throughout the Bering Sea. The largest colonies nest in the outlined areas, generally where nesting sites and food resources are most abundant. Many nutrients are brought into the Bering Sea by currents from the North Pacific, which rise as they sweep over the continental shelf (dotted line). The resultant turbulence causes the highest zooplankton productivity in the light-green area and the highest benthic productivity in the blue-shaded area. The dark-green area is one of low salinity frequented by murres, puffins, and kittiwakes, which feed on its high fish populations.

area has been created as a result of the enormous energy released by the collision of three tectonic plates —the Pacific Ocean plate, the Siberian plate, and the North American plate. The crushing force produced by the movements of these three plates has produced volcanic activity throughout Beringia, including the formation of the Aleutian-Commander Islands chain where vulcanism is still present and active. Vast extrusions of lava cooled rapidly to form fine-grained rocks; ice and pounding waves then broke them down to rubble.

The present landscape along the indented coasts is one of spectacular heaps of rubble and sheer cliffs that rise hundreds of feet. The rubble, ledges, and crevices supply countless nesting sites for sea birds. Pelagic cormorants and black-legged kittiwakes occupy the smaller ledges, and common murres crowd the wider ones, their nests so densely packed together that the birds can scarcely find room to perch. Pigeon guillemots nest in the small holes between boulders at the base of the cliffs. Horned puffins and parakeet auklets nest deep under boulders or in the larger crevices where they are able to escape predation by arctic foxes. Parakeet auklets return to the same nest sites every year and can locate them even when the rocks are buried under snow and ice. Day after day, the birds congregate in pairs or bickering groups on the snow slides covering the rock rubble. As soon as the snow melts, they vanish beneath the boulders.

Even given the climatic variation of Beringia, and its apparently limitless supply of nesting sites, high numbers and populations of bird species could not exist there without an abundant food supply. The Bering Sea is an area of high biological productivity. The proliferation of plankton in the water's upper sunlit, or euphotic, zone is an indispensable key to the biological system. As the ice breaks up in the spring, an unusually rich supply of plant plankton blooms. One explanation might be that low temperatures inhibit plant respiration (which consumes energy) to a greater degree than they inhibit photosynthesis (which traps energy). By early spring, high amounts of plant plankton have accumulated, and the resultant concentrations nourish crustaceans and small fish, which, in turn, attract sea birds and mammals.

Many of the mineral nutrients necessary for production of plankton come from the Pacific Ocean via the deep trenches between the Aleutian Islands. The currents that carry the nutrients form the Bering Sea gyre. The typically strong winds of the south Bering Sea whip the waters of this slow-moving vortex and bring the nutrients to the surface. Part of this current flows over the continental slope and onto the continental shelf, where more nutrients are added by the heavy spring runoff from the Anadyr River of Siberia and the Yukon and Kuskokwim rivers of Alaska. This water mass mingles with deep water from the Anadyr Basin and flows north past the western end of Saint Lawrence Island, through the Bering Strait, and into the Chukchi Sea.

During the long days of the subarctic summer, the nutrients carried in the turbulent waters produce an abundance of plankton. Researchers have found that primary productivity north of the Aleutian Islands creates 250 milligrams of carbon per square meter of water surface per day. In the Bering Sea

Nesting kittiwakes tolerate disturbances better than other Bering Sea birds. But as the area experiences more traffic from boats and planes, researchers expect that mortality among the young will increase.





gyre, they have measured the productivity at 350 milligrams. For comparison's sake, only 70 milligrams of carbon are fixed per square meter of water surface per day in the open seas.

The amount of productivity on the western side of the Bering Strait is even higher. Here, researchers have determined that plant plankton fixes 1,000 milligrams of carbon per square meter of water per day. Although at the low end of the measure of productivity of the world's best-known upwelling systems, such as the one off the coast of Peru, the amount of carbon does make this area one of the most productive in the world. Off Peru, the cold waters that flow north from Antarctica fix 11,200 milligrams of carbon per square meter per day. This high productivity has resulted in rich fisheries and millions of cormorants, pelicans, and boobies. The situation in the Bering Sea is similar.

One group of organisms that takes advantage of the local productivity in the northernmost Bering Sea and Bering Strait is the benthos—bottom-dwelling worms, clams, snails, barnacles, starfish, and shrimplike crustaceans. These animals feed on the remains of plant or animal plankton that constantly sink from the sunlit zone above or are washed into shallow water. In turn, many sea birds and mammals consume the benthos, particularly in the shallows. Sea ducks often dive for bivalves and crustaceans, and shore birds probe for worms and clams on the mud and sand flats of lagoons, inlets, and estuaries.

The distribution of these benthic animals is patchy in the Bering Sea, but their abundance in the Chirikof Basin is spectacular. Whereas bottom samples from Anadyr Gulf and Bristol Bay in the Bering Sea produce 470 and 55 grams of benthos per square meter, respectively, the Chirikof Basin bottom produces 900 grams in the same size sample.

Fish, as well as sea birds and mammals, feed off the benthos, producing heavy catches for Japan and Russia, the two nations whose fishing fleets harvest the area most efficiently. Although some 270 fish species inhabit the Bering Sea, the principal one taken is pollack, which, since the demise of the Peruvian anchovy, has the dubious distinction of being the most heavily utilized fish species in the world. Other abundant species are flounder, halibut, and hake, all bottom fish inhabiting the edge of the continental shelf; salmon in Bristol Bay; and herring in the mid-Bering Sea surface waters. About 4½ million tons of fish are taken annually in the entire area. This compares with some 500,000 tons hauled each year from the waters off New England.

The reasons for bird species diversity in the Bering Sea are, however, far more complex than the mere availability of nesting sites and food resources. Other, more subtle influences, which have long been at work, have allowed more than thirty-four sea bird species to nest here for centuries. Still other forces have recently led additional species to settle in the Bering Sea area. Each year, some species—bar-tailed godwits, wheaters, arctic warblers, and curlew sandpipers—migrate to the Alaskan coast from Siberia. Other species such as dovekies and black guillemots have come from the eastern Arctic Ocean. Some of these have frequented the Bering Sea for decades; others, for only a few years. The reasons are not yet known. It does appear, however, that some of the new settlers came to the Bering Sea merely because they straggled outside of their usual migratory routes.

In most cases, the great majority of a particular population will follow the same habits year after year, whether it be to remain in the same place throughout the seasons or to migrate during the spring and fall. A few individuals, however, will become colonizers. One example is the case of the herring gull population in the mouth of the Saint Lawrence River in eastern Canada. The great majority of these gulls nest within fifteen miles of where they hatched. Occasionally, however, we have found a few pairs from this region nesting in Massachusetts. In a comparable manner, a few birds of various species may wander into the Bering Sea from other areas.

Such wanderers, together with species long endemic to the Bering Sea, may be a source of the species adding to the wide diversity of sea bird life here. In times of disaster—food shortage, environmental disruption, or climatic change, for example—a few members of a population may colonize a new site. Or they may have moved to the site before the disaster struck. But the majority of the population, remaining in the traditional habitat, will be killed off. Occasionally, however, it is just these birds, the stay-at-home conservatives, that survive. This may have been the case in Beringia and might account for the many species that have traditionally nested in the Bering Sea. When the Pleistocene ice sheets moved south some 20,000 years ago, parts of present-day Alaska and the Bering Sea escaped glaciation, even though most of Canada and much of the northern half of the United States did not. Botanists have concluded that this ice-free zone was at least partially responsible for Alaska's diverse present-day flora. This reasoning could well be extended to include the Bering Sea's high number of endemic species of sea birds.

That such diversity of sea birds, as well as other animals and plants, occurs in such high latitudes as the Bering Sea is remarkable considering the paucity of species in many other high-latitude regions. From a comprehensive ecological viewpoint, however, the diversity follows the generalization that species abundance is greatest where regional topography and local climates are varied, where biological productivity is high, and where historical accidents have allowed the perpetuation and enrichment of flora and fauna. □

Although kittiwakes nest on narrow ledges, relatively few chicks die from falls because they rarely wander from the nest. Most often they sit or stand motionless, their backs to the cliff face.

Buzkashi

by Asen Balikci
photographs by Jim Sheldon

To local chiefs in northern Afghanistan, a game that resembles a cavalry charge is a contest for prestige

Buzkashi, which means "goat dragging" or "grabbing," is an exceptionally violent game that tribes in northern Afghanistan (Afghan Turkestan) play on horseback. Besides expressing the fierce and incessant social rivalry that preoccupies Afghans, *buzkashi* also indicates the important role that the horse has played in central Asian history. Early armies of nomadic horsemen could assemble quickly, cover great distances, attack, and at full gallop and without dismounting, sweep up women, animals, and plunder. Genghis Khan used cavalry to establish an empire that stretched from northern China to the Mediterranean. He then employed mounted couriers to transmit orders and news over his empire's routes.

Although *buzkashi's* historical origins are unclear, they may lie in a traditional exercise of central Asian horsemen, who trained by riding, in turn, past a ditch and attempting to pick up a beheaded goat, or *buz*. No one knows when this exercise became a game in which all riders simultaneously attempted to seize the goat, which is now a calf carcass.

Of the many Afghan sayings concerning horses, one is, "Better to have a poor rider on a good horse than a good rider on a poor horse," an expression of the Afghan belief that *buzkashi* belongs to the horse. In northern Afghanistan, the horse is the focus of complex personal and tribal ambitions and rivalries. Chiefs feel that their honor is closely tied to the qualities of their horses and will spare no amount of expense and energy on feeding and exercising their animals—and on the rituals surrounding them. Horse racing, once an important form of competition, has largely been replaced by the more violent pastime of *buzkashi*. One Afghan explained: "Everything in *buzkashi* is rivalry."

The groups involved in *buzkashi* on the vast plain of northern Afghanistan are primarily Uzbek and Turkoman (Turkic-speaking) populations, seminomadic sheep breeders and dry farmers who migrated across the Amu Darya (ancient Oxus River) from Central Asia. Among them live large groups of Persian-speaking Tajik, who excel at irrigation farming, and more recent settlers like the Hazara, of Mongol origin, and the Pushtuns, who are either farmers or nomads.

Hence, in a day's walk in the Narin-Burka area of Baghlan Province in northeastern Afghanistan, a traveler encounters a mosaic of people, languages, and customs. Along the Narin River in the lowlands, Pushtun settlers occupy the best-irrigated fields. On the small, dry plateaus nearby, Pushtun nomads pitch their black tents. Slightly higher, but drawing irrigation water from the same river, live Hazara settlers. Higher still, on a plateau without irrigation water, reside Uzbek horse and sheep breeders who summer on their mountain grazing sites in round felt yurts. Farther up, on the slopes of the gorges of the Hindu Kush, are the stone houses of Tajik gardeners, and in the mountains above them, at an altitude of nearly 9,000 feet, the Gujjar, who practice no agriculture, graze their goats.

The original inhabitants of the area were the Uzbek, but after the Afghan government had consolidated its power in Turkestan at the beginning of the twentieth century, other, non-Turkic groups slowly began to settle there. Now Narin-Burka contains the three main segments of Afghan society: nomads, sedentary farmers, and city-bazaar communities, the economic and administrative centers where handcrafted goods are made and imported goods and local produce redistributed. In the city-bazaars reside almost all government officers—the regional governor, the police chief, the military commandant, the tax collector, the chief justice, the regional school superintendent.

The area's local political leadership is represented by the chiefs, or *khans*, of groups of kinsmen that anthropologists call lineages. The chiefs compete endlessly among themselves for prestige and dominance in every area: wealth, tribal leadership, land, hospitality, entertainment, wisdom, insolence to government officials, owning the best *buzkashi* horses, and hiring the best *buzkashi* riders. *Buzkashi* is one expression of the chiefs' interminable rivalry, but the game itself can independently inspire antagonisms.

The office of chief is not hereditary, and there are no clear-cut rules of succession. Local chiefs actually have no well-defined political or judicial powers, yet their influence as brokers in political and economic matters is substantial. Chiefdom is based on wealth—usually amassed, sometimes inherited—and on a quality called *khanzada*, literally, descendant of a chief. Within a particular lineage, practically all the rich, or would-be-rich, aspire to become chiefs.

During a buzkashi *match each rider, or* chapandaz, *tries to seize the* buz, *which means "goat" but is actually a calf carcass, and break away to score.*



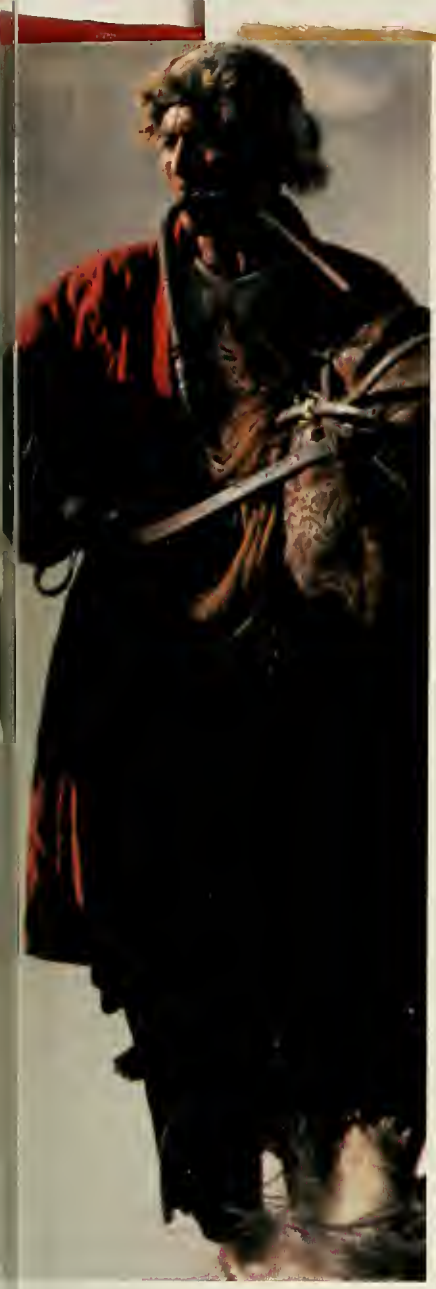


This ambition harnesses an individual's entire energy and encourages ruthlessness and constant political scheming.

Once a man becomes a chief, he dare not lower his guard, for all chiefs compete against each other for supremacy, employing innumerable stratagems: stealing a rival's fiancée, burning his fields, purchasing evil charms to destroy his flocks, luring his clients with gifts and promises, keeping superbly decorated guesthouses, providing lavish entertainment, and most important, keeping the best *buzkashi* horses mounted by the best riders (*chapandaz*). Serious and often deadly rivalry is the essence of Afghan social life, giving it a theatrical quality reminiscent of displays of wealth in West Coast Indian potlatches. Rivalry is by no means limited to the rich. According to one popular aphorism, "A woman is a rival of a woman, a shepherd is a rival of a shepherd, and a chief is the rival of a chief."

Traditionally, concern with horses and the associated *buzkashi* game was part of Turkic-Uzbek culture. Non-Turkic settlers in the Narin-Burka area quickly borrowed the main elements of this horse complex, which is now firmly entrenched in common regional culture. In Narin-Burka, people keep three kinds of horses. They never boast of, indeed, rarely speak of, workhorses. Considered inferior animals, workhorses are used for loading goods, riding to the bazaar, operating oil mills, and very rarely, plowing. They are considered lowly animals and are often worked to exhaustion.

Narin-Burka's riding horses belong to a higher class. People know these horses as individuals and can describe all their characteristics: color, height, shape of head or legs, speed and endurance, past performances. Pushtuns have had a predilection for speedy riding horses, and one local tribe breeds them. In Pushtun areas of southern Afghanistan, ceremonial occasions



The chapandaz *at far left clasps the heavy, awkward* buz *under his leg. Trying to make his way to the goal, he collides with another rider.*

include formal horse races and spectacular equestrian exercises. Pushtun settlers in the north continued these practices until they were recently replaced by *buzkashi.* However, I came across one incident of a spontaneous race.

Haji Omar, chief of the Lakenkhel lineage of the Pushtuns in Narin, was riding back from bazaar with his client Qul and his rival Wakil Abdulajan. Qul owned a mare of excellent reputation, which Haji Omar was riding, while Qul had mounted Haji Omar's sturdy stallion. Wakil Abdulajan was trotting near them when he suddenly pushed ahead. A race began. Haji Omar excitedly whipped his horse, and Qul followed suit. As Wakil Abdulajan moved ahead, the lagging Haji Omar felt his prestige endangered, and shouted at Qul, "Catch this scoundrel; push my horse as fast as you can." Wakil Abdulajan's lead lengthened, and Haji Omar's anger grew accordingly: "Qul, dismount, you are shaming my horse, and you will see how I am going to catch that infidel." They changed horses, and mounted on his own mare, Qul overtook the rival. Although Haji Omar finished last, his prestige remained undiminished because his rival had been defeated. At any time, latent rivalries can inspire such contests.

The importance of *buzkashi* in chiefs' rivalries means that in Narin-Burka, horses bred for the game are highly prized animals. At a colt's birth, it is not allowed to touch the ground, lest "its wings be taken away." Generally, only stallions are used for games. During informal *buzkashi* games, a young horse is trained to dodge, attack, and respond to its rider.

In 1955, the Afghan Olympic Committee made traditional *buzkashi* an organized sport. This official form now has regulations governing all its aspects: who can play, team size, length and schedule of games, scoring, field size, breeding of *buzkashi* stallions, playoffs, and championships.

But village *buzkashi* has few rigid rules. Playing grounds, located near most villages and towns in Afghanistan's seven northern provinces, should be grass covered and free of rocks, to avoid hurting horses' hoofs. *Buzkashi* in Narin-Burka is a winter game; the season usually begins in the autumn, after the rainfall, and concludes shortly after the Muslim New Year's Day, March 21. If playing went on during Afghanistan's very hot summers, the horses would suffer and clouds of dust from dry fields would blind the riders.

All summer the horses are kept in courtyards to rest, but in October they are taken out and exercised—at first for only a few minutes a day, but working up to progressively longer and faster trips. In Narin-Burka, their off-season diet is clover and barley, and in winter their ration of barley is much larger.

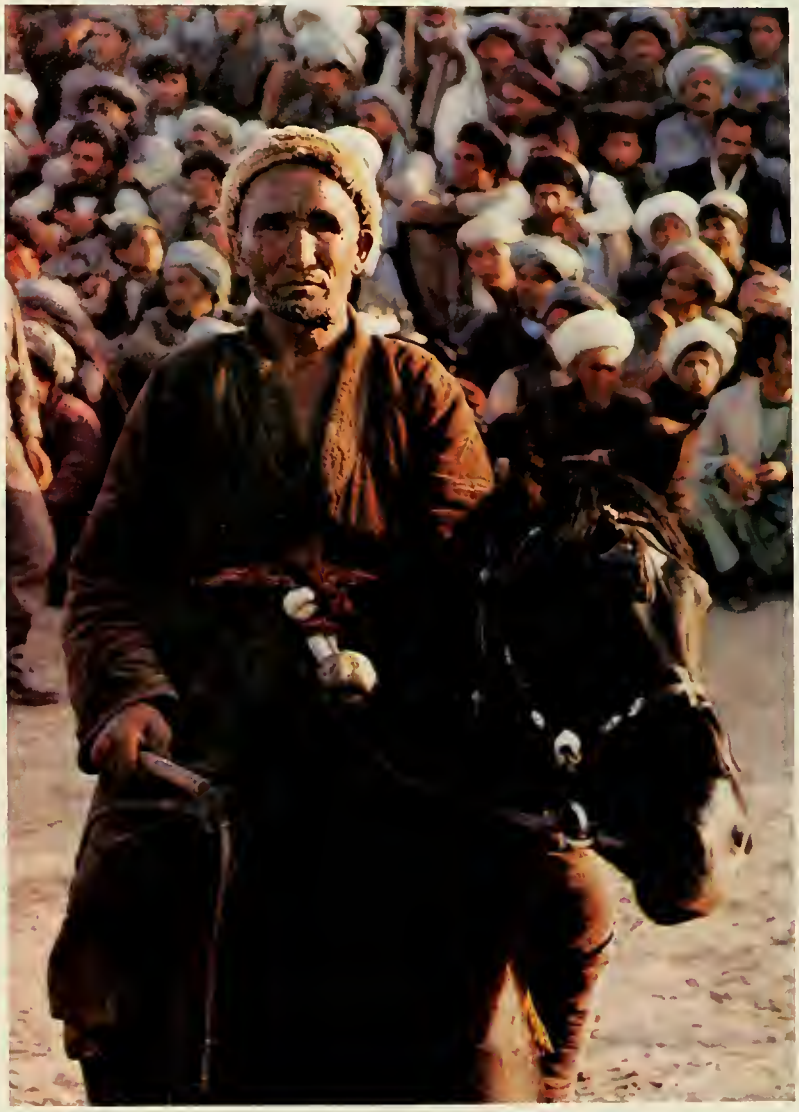
Late November brings the first, short *buzkashi* matches. Only in mid-December does serious *buzkashi* begin. Every Friday afternoon in the villages, the horseowners (who are *khans* of various ranks), the mounted *chapandaz* (rarely including more than a dozen active players), and a crowd of onlookers gather on the game grounds. In one version of the game, the field itself has no precise boundaries. On one side stands a line of mounted horseowners, elderly and influential people, and government officials. In addition to these notables, several rows of spectators sit on the ground. In front of the elders is the goal, a circle about ten feet in diameter, outlined with gravel or sand. In the opposite direction, at a distance that depends on the field size and the number of horses, a pole is stuck in the ground.

The game president (*rais*) places the *buz* in the goal. The *chapandaz* then struggle briefly until one of them manages to grab the carcass. The lucky horseman is then supposed to round the pole and return to the goal. If he manages to throw the *buz* inside the circle, he wins a point. En route, however, he has to face the other *chapandaz,* who try to take the *buz* away from him. The ensuing violent clashes are the game's *raison d'etre,* the enactment of horseowners' political rivalries. *Chapandaz* say that the horses develop their own rivalries and will spontaneously bite and kick each other. This game may continue indefinitely, until the *buz* or two or three carcasses have been torn to pieces.

In Narin-Burka, most horseowners pay cash for their animals. The average price of a good workhorse is 3,000 afghanis (the exchange rate is currently forty-five afghanis to the dollar), while an







Each chapandaz *is underwritten by a wealthy chief, who regards his rider's losses on the* buzkashi *field as a great blow to his honor.*

exceptional *buzkashi* horse can sell for about 60,000 afghanis. Narin-Burka's *buzkashi* horses have long pedigrees. Some are bred locally, others purchased on the plains along the Amu Darya, northwest of Narin-Burka. Two influential Uzbek chiefs breed *buzkashi* horses, but only sell in distant regions where they can command high prices.

Some owners frequently change horses. Haji Omar once owned a very good horse, apparently undefeated. His rival, Wakil Abdul-ajan, swore publicly to defeat the animal, and in the effort, he bought and sold over twenty horses. Only his death finally canceled his plan.

A chief places his *buzkashi* horse in the center of his large courtyard. When guests arrive, they see the horse first and comment eloquently on its virtues. The owner's swell of pride is great, but no greater than his shame when his horse has performed poorly on the field. One Afghan declared, "It is better to shoot a chief with a gun straight in his face, than to tell him loudly on the *buzkashi* field that his horse is weak and not fast enough." A chief will consult a shaman, who goes into trance to predict whether a young horse will become a good competitor. Chiefs also pay other holy men fat fees for protective amulets that are hung on the horse's neck. Certain individual horses are famous not only in Narin-Burka, but all over northeastern Afghanistan. One is the undefeated "golden horse," whose pedigree supposedly originates in Samarkand. People say that after every success, the golden horse dances like a colt all the way home.

After the horse, the second important factor in *buzkashi* is the *chapandaz*. *Chapandaz* are recruited during informal local games, played without *rais* near villages. To earn a prize, a rider must seize the *buz*, and breaking free of the pack, ride away in any direction. Young boys enter these games, observing the methods of experienced *chapandaz*, who are not considered ripe until their mid-thirties or early forties, and who frequently compete in their fifties. The older *chapandaz* casually instruct the boys. Chiefs stand by, on the lookout for agile recruits.

A chief spares no expense to secure the finest animals; he also safeguards his prestige by going after the best riders. Usually, every *chapandaz* is attached to a particular chief, who offers him gifts and protection.

Relations between *chapandaz* and chief are always cordial and friendly. A careful chief wants his *chapandaz* to have the best available equipment. Before the *buzkashi* season opens, the *chapandaz* receives a fine new coat, a fur hat, and woolen socks. On the playing field, as soon as the *chapandaz* has scored a point, the chief announces his gift or prize—usually money, occasionally a turban. His whip raised high to call attention to his score, the *chapandaz* rides forward to take his prize as the onlookers leap to their feet, cheering his name. During the season, the *chapandaz* receives additional presents of grain and money. One wealthy chief was so fond of his *chapandaz* that he gave him his daughter in marriage.

Unless he is a close relative of the chief, the *chapandaz* does not supervise the daily care of the horse or horses that he habitually rides.



Above, turbaned spectators on the sidelines cheer their favorite riders. At right, a chapandaz, *who has made off with the* buz *and scored, proudly shows off his prize of a quilted coat and a bag of soap.*



Chiefs believe that only kinsmen can take proper care of horses. Nor does a *chapandaz* ride only his master's animal. During a game, he will ride one horse for no more than ten or fifteen minutes. Then the horse is allowed to rest, and the *chapandaz* mounts horses belonging to his master's kinsmen, political allies, and clients. These horses stand saddled near the field and are brought to the *chapandaz,* who may accept or refuse freely. *Chapandaz* may even mount horses belonging to their master's rivals, although during important regional games such behavior might be considered bad taste. In the Burka area, only one *chapandaz* receives a regular salary from his master, and therefore is not allowed to mount a rival's horse.

The chief must also watch over his rider's safety, for *chapandaz* are rivals to each other by definition. In principle, every *chapandaz* struggles alone and competes with all other *chapandaz* in the arena. In actual fact, *chapandaz* form three kinds of coalitions. Some outstanding riders become so well known that they travel to Kabul, the capital, to play before the president. These players adopt haughty attitudes befitting stars, and acquire young admirers, who act as their satellites on the playing field, collaborating in game strategy.

A second kind of coalition reflects a chief's political alliances. If he is powerful, he can surround himself with lesser chiefs, whose *chapandaz* support his own riders. During regional games, *chapandaz* from the same tribe will align them-



selves in a third type of coalition. Uzbek *chapandaz* will help each other against Hazara and Pushtun riders, and vice versa.

In the arena, a coalition of *chapandaz* may use all sorts of tricks to foil a dangerous rival. When he bends down to grab the *buz,* several horsemen may make their horses rear to strike him as he heaves himself up. As he rushes toward the goal, *buz* in hand, his enemies may cause a collision. Under these circumstances, the chief can scream, announce irregular behavior, and call for the intervention of the *rais.* He may also resort to lobbying, passing gifts of money among other *chapandaz,* and eventually establishing an ad hoc countercoalition.

In Narin-Burka, two ethnic groups, the Awkhana Pushtuns and the Kogaday Hazara, practice one-upmanship by making extravagant efforts to recruit talented riders. For a long time, the Kogaday were far superior, thanks to three outstanding *chapandaz,* Jabar, Bazmir, and Bazmir's brother, the great Bazgul. Bazgul was extremely arrogant, respecting nothing and no one, not even the Pushtun elders. He and the other two Kogaday inflicted defeat after defeat on the Pushtuns, until they could not even touch the *buz.*

Haji Omar, chief of the Pushtuns, could no longer endure this humiliation and declared that something had to be done. In council, the elders decided that buying better horses was not the answer, and that the only feasible strategy was to break the coalition of the three Kogaday *chapandaz* by attracting one to the Pushtun side.

Since Bazmir and Bazgul were brothers, they were considered incorruptible. So the Pushtun *chapandaz* brought Jabar presents, invited him to feasts, slaughtered fat sheep in his honor, and flattered him, saying that they wanted him to teach them. For Jabar, this was a dangerous proposition: if he accepted, the Kogaday reprisals would be terrible. At this point, the Pushtun elders intervened and offered Jabar full protection, cash compensation for any losses, and in the event of a fight or feud, the support of the whole Pushtun lineage, guns in hand.

The strategy worked: Jabar joined the Pushtun *chapandaz,* pulled the *buz* from Bazgul's hands, and saved the honor of the Pushtuns. Heartened, Paindamangal, another Pushtun *chapandaz,* started using tricks against Bazgul. Paindamangal would lock the leg of the *buz* against his stirrup and place his foot so that Bazgul could not pull the *buz* out. While in full gallop, Paindamangal would counter Bazgul's pull by sliding down the horse's opposite side, right under its belly. The Pushtuns say that since then Bazgul has behaved like a normal human being.

Because the reputations of *chapandaz* go up and down, even the greatest live in fear of enemies, injuries, and bad luck. They frequently visit the shaman to ask the outcome of forthcoming games, and to learn whether their rivals have strong protective talismans or some evil medicine that will bring misfortune. In trance, the shaman calls his spirit protectors; with their help, he tries to "raise the star" of a *chapandaz,* to make him feel strong and confident. If the strongest magic is invoked, the *chapandaz*'s rivals in the arena may suddenly see him as an enormously powerful giant.

During play, the chief can do little except watch, pray, curse, and perhaps award prizes. But *buzkashi* could not exist without wealthy chiefs. Year round, chiefs breed, buy, and sell horses, lavish them with care, try to attract the ablest *chapandaz* and secure their loyalty, provide horses and riders with the best gear. Since these are expensive projects, *buzkashi* is an aristocratic game, a political strategy. If one chief's prestige begins to approach another's, the two automatically become *buzkashi* rivals.

One great Pushtun chief in Narin, Arbab Jonmamat, married his son to a girl from a village near the bottom of Awkhana valley. The girl's family gave a feast in their house, but did not invite the Lakenkhel lineage. Its chief, Haji Omar, saw a chance to avenge this insult when the wedding procession, which brought the bride to her husband's house, had to pass through his territory. The procession was preceded by a group of *buzkashi* players, kinsmen of the bride and bridegroom. Throughout the singing and merrymaking, the riders played informal *buzkashi* continuously.

When the joyous procession reached Lakenkhel, Haji Omar ordered his *chapandaz* to bring their horses and capture the wedding party's *buz,* which they did easily. Jonmamat hurried over and begged them not to ruin the feast and to return the *buz.* After waiting long enough to humiliate Jonmamat, the Lakenkhel returned the *buz.* When the game resumed, the Lakenkhel again attacked and took the *buz.* This time, they refused to return it.

Besides the chiefs, the other members of a *buzkashi* audience are also important to the game. This audience is hardly passive. Varied ethnic groups and members of different lineages, each supporting their own *chapandaz,* will scream, shout, encourage, and criticize. Galloping horses may overrun the semicircle of onlookers, wounding some. If a quarrel breaks out among *chapandaz,* the spectators immediately join in, and as sticks and stones fly in all directions, a general battle begins. *Buzkashi's* violence brings to mind medieval tournaments.

In recent years, *buzkashi* games have become more frequent. At the end of the nineteenth century, during the last part of Afghanistan's feudal period, tribal chiefs faced a weak central government, and fought continually among themselves for supremacy. Since the beginning of the twentieth century, the central government has gradually grown stronger. Simultaneously, *buzkashi* has replaced actual warfare as the most visible manifestation of the chiefs' political ambitions. □

Horse whip and fur cap in hand, a chapandaz *takes time out from the field, where his opponents will try any number of brutal tricks to keep him from the* buz.



The Elegant Symmetry of Crystals

by Rodney C. Ewing

Despite their variety, all these substances fall within an amazingly small number of classes

Even a short visit to a collection of minerals and gemstones will impress the viewer with the beauty and diversity of the specimens. There are about 2,500 naturally occurring minerals. Each is unique in size, color, and form, but the careful observer immediately begins to notice the similarities. It is these similarities that allow us to classify minerals into different groups, according to their constituent atoms and the arrangement of these atoms within the crystal structure. The shape and orientation of well-formed crystal faces provide the key to understanding the internal structure of minerals, and it is on these crystal faces that we will first focus our attention.

In the earliest stages of natural science, well-formed crystals were placed in the same category as fossils, being considered "tricks of Nature" placed on earth by God to test the faith of man. Ancient descriptions of crystal forms, such as those by Pliny the Elder (A.D. 23–79), were brief and barely referred to the shape or arrangement of the crystals' faces. Not until the seventeenth century were the first critical observations made. Then Nicolaus Steno (a Latinized version of the name of the Danish physician Niels Stensen) noted that crystal growth "does not take place from within, as in plants, but only by the deposition of minute particles, brought from the outside by some liquid, on the external planes of the crystal." This was the first effort to clearly separate the mechanisms of organic growth from those of crystal growth. In his study of quartz, Steno found that, regardless of their shape, similar faces make the same angle with one another. That precept was the first formal statement of what is now known as Steno's law, or the law of constancy of interfacial angles: the angles between corresponding faces on different cyrstals of one substance are constant.

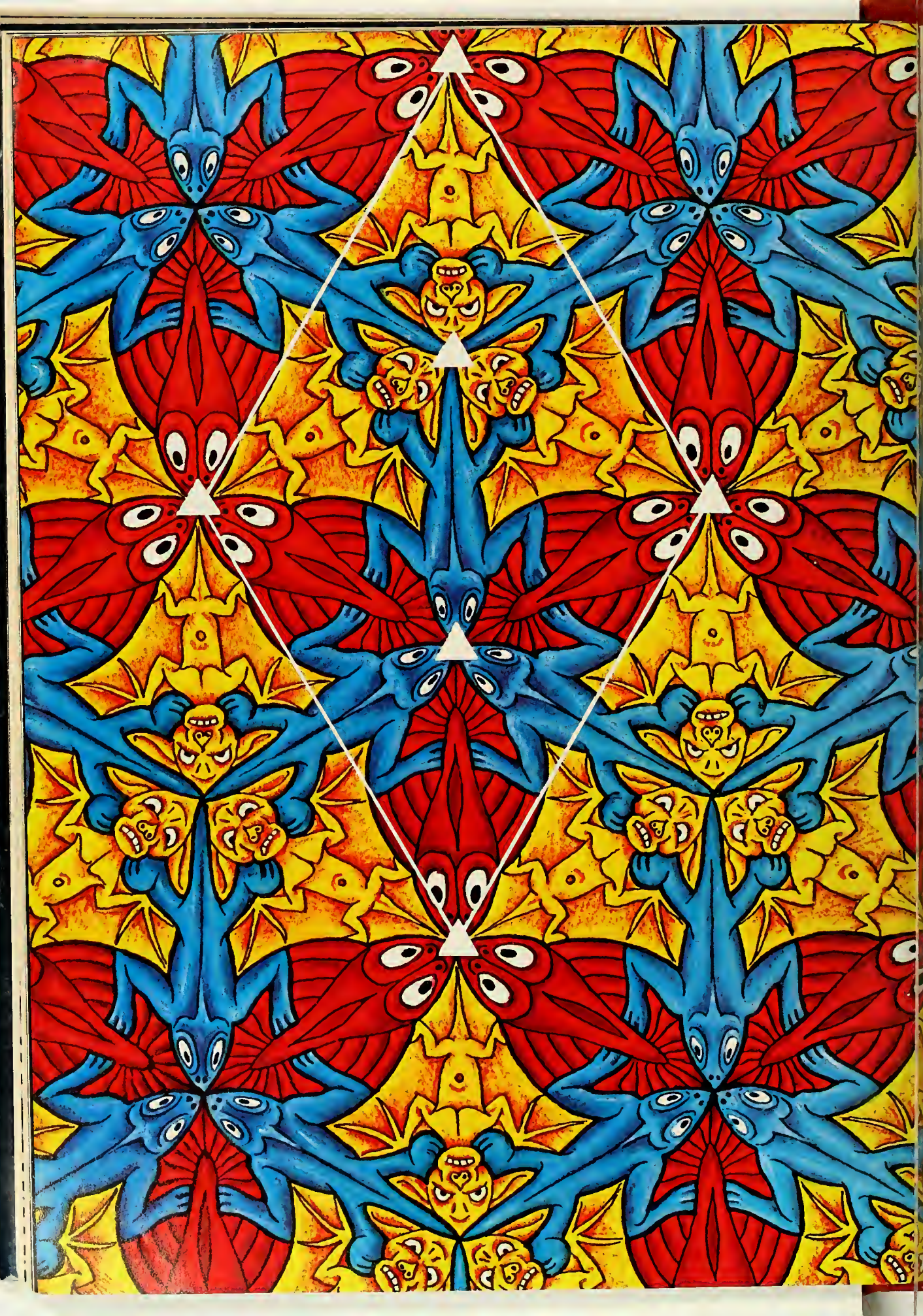
These two observations on the growth of crystals and the relationship between faces mark the beginning of the science of crystallography and the efforts of crystallographers to systematize crystal forms. Much influenced by the success of Linnaeus's classification of the organic world, eighteenth-century crystallographers continued to measure and classify minerals. By 1800, five hundred substances had been carefully measured and described. In the same way that Linnaeus's *Systema naturae* was woven into Darwin's theories, these early morphological studies became the basis in the middle of the nineteenth century for the mathematical classification of all the known minerals into thirty-two groups.

That well-formed crystals, with their strikingly planar faces, although diverse in shape, size, and form, could be grouped into only thirty-two classes is an important key to understanding the internal atomic structure of minerals. The same principles that limit the arrangements of repetitive patterns in wallpaper and tiles can also be used to classify crystal forms. The trick to understanding the limitations on two-dimensional patterns or the arrangement of three-dimensional crystal faces is to look for some relationship between the different component parts. Essential to the process is the concept of symmetry—the exact repetition in size, form, and arrangement of constituent parts on opposite sides of a plane, a line, or a point.

In dealing with crystals, we must look for simple geometric processes that will relate individual crystal faces to each other. These geometric steps—called symmetry operations—might involve such movements as rotation or mirror reflection. The limitation on the results of symmetry operations and their possible combinations is the cause of the limited number of crystal classes. The beauty of this approach is that it is independent of the minerals themselves and yet confirms a classification system that was originally based on years of careful and tedious observations of the number, shape, and orientation of crystal faces on mineral specimens. Before discussing the classification system further, let us take a quick look at the internal structure of minerals and identify their basic building blocks.

The arrangement of atoms in minerals is much the same as the regular, repetitive, two-dimensional patterns of wallpaper, Moorish ornamentation, or the etchings of the late Dutch artist M. C. Escher, except that in minerals the arrangement is three dimensional. The regularity and order of the atoms in minerals result from the lower total energy of a crystalline solid as compared with the disorder of a liquid or gas because of its higher energy.

te, photographed by Henry Jansen



To describe any regular pattern, be it that of wallpaper or atoms, it is not necessary to portray the entire pattern; it is sufficient instead to choose some basic motif (there may be several) that, when repeated continuously through two or three dimensions, will re-create the whole. In minerals, the three-dimensional motif that fills this role is called the unit cell.

The importance of the concept of the unit cell was first realized by René Just Haüy, an eighteenth-century French crystallographer. Many minerals have a variety of crystal forms. Haüy noted that the variation for any particular substance might be explained if the different forms resulted from different stacking sequences of the basic unit cells, or as he called them, *molécules constituantes*. From the cleavage angles, that is, angles between planes along which a crystal might break, Haüy deduced that there were six different but primitive forms of the unit cells. Further, he showed that if crystal faces consist of a stacking of unit cells, then the angles between the faces will be determined by the relative dimensions of the unit cell and the particular type of stacking sequence.

The unit cell not only determines the angles between the faces of a crystal but also exhibits all the chemical and physical properties of the mineral. The dimensions of the unit cell, on the order of one hundred millionth of a centimeter, and its contents vary from substance to substance, but each cell is a building block containing all the information required for the construction of the entire mineral.

Within each unit cell, there may be additional geometric principles in operation that relate the positions of the atoms within the cell to one another and thereby create additional symmetries. The presence of symmetry within a unit cell provides crystallographers with a precise shorthand for describing the structure of crystalline matter. Instead of describing the position of every atom throughout a given crystal, a number that would be at least in the billions, a crystallographer need only locate the atoms in a single unit cell. If atoms of the same kind within that cell can be related to one another by the rules of symmetry, it is sufficient to locate only one of the atoms within each unit cell. The remaining atoms of the same kind can then be generated by the application of symmetry operations.

Thus, a determination of the positions of particular atoms within a unit cell, combined with the appropriate symmetry operations, makes possible the description of the structure of a specific mineral with a beautiful economy of thought. The real saving in time and effort, however, comes with the realization that although symmetry operations in a unit cell may exist in combination with one another, the total number of allowed combinations of symmetry elements within the unit cell is only 230. These 230 combinations are known as space groups. The number of possible symmetry combinations describing the arrangement of crystal faces is more limited—numbering 32—because of the restriction that imaginary lines representing axes of rotation and the planes of mirror images must intersect at a common point. For the purpose of illustration let us return to two-dimensional examples.

A student of repetitive patterns such as those found in wallpaper is confronted with a seemingly infinite diversity. If instead of considering the patterns themselves, we concentrate on the types of symmetry in the patterns, regularities quickly become apparent. There are only two basic types of symmetry operations in two-dimensional patterns. The first operation causes the reflection of the basic motif across an imaginary plane to match another part of the pattern. This is analogous to the reflection we see in a mirror. The second involves rotation and causes the pattern to repeat itself as it is rotated around an axis perpendicular to the pattern. If the letter *s*, for example, is rotated 180° on a page, it repeats itself perfectly. A similar result is obtained when a square is rotated through 90°.

Symmetry operations cannot be combined with one another in such a manner that they destroy the symmetry of the pattern. This qualification limits the allowed number of combinations. Mirror planes, for instance, must be either parallel to each other or at an angle of 30°, 45°, 60°, or 90°. Arranging the mirrors at any other angle, say 73°, results in an infinite number of new mirror planes. A further restriction is that the combination of symmetry operations must be compatible with repetition of the motif that will fill the given space. For example, a regular pentagon is an object that repeats itself five times in a rotation of 360°, but if we try to tile a floor with regular pentagons, cracks and spaces will inevitably result. The cracks and spaces make for a poor bathroom floor as well as an impossible crystal structure.

The allowed combinations in two dimensions can be derived mathematically or empirically by careful observation of two-dimensional patterns. By using either method we must conclude that there are only seventeen possible combinations of symmetry operations that will produce repetition of patterns in two dimensions. The infinite diversity of repetitive patterns in the two-dimensional world of tiles and wallpaper is thus reduced to only seventeen possibilities.

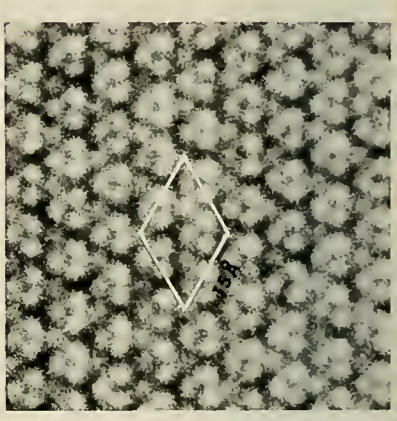
For minerals, we must of course expand to three dimensions. With the addition of another dimension, the number of symmetry operations also increases to include more processes than simply rotation and mirror reflection. The number of

The periodic drawings of M.C. Escher are often used by crystallographers to teach the principles of symmetry. The white diamond superimposed on this design outlines the motif, or unit cell, of the pattern. Repetition of this unit cell in directions parallel to the sides of the diamond generates the entire pattern. When the unit cell is rotated 360° around axes located at the white triangles, the pattern is repeated three times.

ntasy & Symmetry The Periodic Drawings of M.C. Escher, by Caroline H. MacGillavry. Harry N Abrams, Inc.
urtesy of Escher Foundation—Haags Gemeentemusem, The Hague.



Tourmaline, AMNH



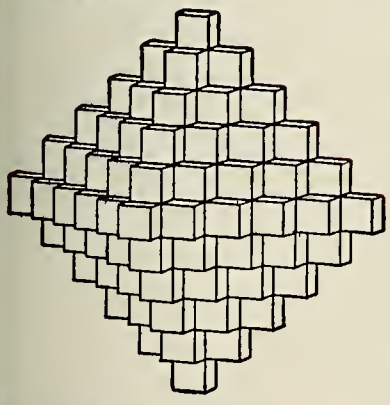
Tourmaline is an abundant mineral found in many locations and in a wide range of colors. The green crystals embedded in quartz, at right, come from Brazil. Above is a high-resolution electron miscroscope image of a section of Brazilian tourmaline. The white line outlines the two-dimensional unit cell in this thin portion of the crystal. Although the patterns of the Escher drawing on page 66 and of this tourmaline are different, their respective unit cells have the same shape.

Henry Jar





Manual of Mineralogy, 19th Edition, John Wiley & Sons



The manner in which three-dimensional unit cells are stacked accounts for the different orientations of crystal faces. The schematic diagram, above, by the eighteenth-century French crystallographer Haüy, shows the stacking sequence of fluorite, shown at left.

possible combinations therefore necessarily increases to include such new symmetries as that found in a spiral staircase, but the allowed combinations still remain amazingly limited. Consider the symmetry operations needed to describe the external form of the faces of a crystal. In this case, as already noted, there is the fortunate limitation that all the operations must intersect at a point within the crystal. The allowed combinations are accordingly called point groups and, as previously stated, there are only thirty-two of them. The symmetry observed in the different faces of any crystalline material must fall into one of these groups. Not all crystalline materials, of course, display smooth, plane-bounding surfaces. Growth in confined spaces and variations in conditions of crystallization may inhibit or distort the development of crystal faces, but where faces are developed, the angles between similar faces will always be constant, and the combinations of symmetry operations relating the faces to each other will always be one of the thirty-two possibilities.

Let us now delve past the symmetries of the external form of crystals and consider the symmetries of the individual unit cells. Here the number of allowed combinations increases because the symmetry operations of individual unit cells, unlike those of crystal faces, do not have to intersect at a central point in the crystal. Each unit cell is repeated throughout the entire mineral. The result of this repetition is the creation of new symmetries. When the thirty-two point groups are combined with repetition in three-dimensional space, the total number of possible combinations reaches 230. These 230 space groups were independently derived in the late nineteenth century by a Russian crystallographer, a German mathematician, and a gifted British amateur. The 230 space groups represent all of the possible combinations of symmetry operations with unit cell repetitions that are required to describe the crystalline state. The derivation and compilation of these groups make possible the routine determination of the structure of all crystalline solids.

The designation of the 230 space groups, which describe the arrangement of atoms within a crystal, preceded the ability of crystallographers to actually make such determinations. Until the early part of the twentieth century, crystallographers were limited in the types of structural measurements they could make. An instrument called a goniometer was used to measure the angles between faces, and the polarizing microscope provided information on the interaction of polarized light with crystals in different orientations. Neither instrument, however, provided detailed information about the internal structure of minerals.

The discovery of X-rays by Wilhelm Roentgen in 1895 provided the necessary tool. In May of 1912 an experiment was completed at the University of Munich in which an X-ray beam was directed at the surface of a crystal of copper sulfate. The diffracted X-ray beams were recorded on film and the symmetrical pattern of the dark lines and points on the film were related to the internal arrangement of atoms in the crystal.

William Lawrence Bragg, a graduate student at the University of Cambridge, was quick to seize on the importance of those results. He examined the structure of rock salt with X-rays and tested a structure postulated for it in 1883. Confirming the structure of salt, Bragg began a systematic X-ray examination of other crystal structures. In 1919 a Swiss mineralogist showed that the space groups of minerals could be determined by X-ray diffraction. Since that time, X-ray crystallography has been critical in the study of the solid state, and structures that could only be guessed at from their external form have been confirmed by X-ray diffraction.

The external morphological measurements of the eighteenth century, the mathematical derivation of point and space groups in the nineteenth century, and use of X-ray diffraction in the twentieth have thus been combined to provide today's understanding of the internal structure of minerals. □

enry Jansen

THE DUST STORMS

. . . and the sun became black
as sackcloth of hair, . . .
Revelation 6:12

There's something medieval about the Great Plains. Partly it's the land, so flat and so immense, spread out like a wall-to-wall carpet from the Rockies to the Mississippi, from Canada to the Gulf of Mexico. Such a land can make one believe that the world itself is flat: its four quarters perfectly balanced by the four cardinal directions; its one God safely ensconced in a zodiac heaven held up by the pitchforks of Justice, Prudence, Temperance, and Fortitude. And partly it's the Gothic sky vaulting overhead, a sky even more expansive than the land. Thunder and lightning can play tag across this sky without crowding the sun; cumulus clouds can pile up like mountain ranges, yet fail to blot out its blue. Here the age-old litany of the wind, the "persistent, mournful crying wind of the plain," as Hamlin Garland put it, blows impartially on the just and the unjust. Here the single eye of the sun, blazing indifferently on good and evil, is rarely out of sight. Under such a sky, time itself seems eternal.

The immutability of the Great Plains, its vastness, the stark emptiness of so much undifferentiated space is awesome, or would be if the settler hadn't divided the land in such a simple mathematical way: a plain geometry, as it were. Rectangularly shaped states right-angle one another, then break into checkerboards of counties, which separate into identical square-mile townships, which section into acres, which divide, ultimately, into cornfields—or occasionally multiply into a town halved by its Main Street; then subdivided into dozens of identical blocks, lots, and yards. Such simplicity, such thoroughness, seems in itself medieval.

Small wonder, then, that when the dust storms of the 1930s rolled over the Plains—their turbulent black clouds pitching and heaving thundersqualls that showered dust instead of rain—some feared they were witnessing the apocalypse. The land, which had seemed so clearly defined, began to move: from field



BY MARILYN COFFEY

Excerpt from a chapter of a forthcoming book. © 1977 by Marilyn Coffey



Arthur Rothstein, FSA

to field, from county to county, from state to state. The distinction between land and sky, once so clear, became blurred as earth rose up to dance before the wind in a dozen different guises. Thousands of tons of soil, once indisputably wed to the land, rose and invaded the stratosphere. Such a reversal of the physical world was shocking.

But as each early storm passed, the sense of the apocalyptic died away with the wind. Dust storms, folks reminded themselves, are a normal part of life on the Plains, where dry weather and high winds traditionally combine to shift soil, where the settler complained in the 1800s about storms that left him sooty as a coal miner, where Indian villages were buried in dust as long ago as the fifteenth century, and where, eons earlier, the fertile loess itself had been blown in from the Rocky Mountains. In retrospect, it hardly seems remarkable that most people chose to dismiss the storms. There was something so arbitrary about them, so capricious. No two were quite alike. Some rolled in as magnificently as thunderheads; others shrieked in like relentless tidal waves. Some crept in like fog, clinging insidiously to the ground, then swelled until sky and land fused into a brownish pall. Others fell in a second, a pitch-black blanket unfurling, a thick whirling cloud of dust dark enough to turn day into midnight. Still, when the first of the great dust storms hit in November of 1933, even hardened newsmen were impressed. Originating in Saskatchewan Provence in Canada and driven by gale-force winds, the storm swept through the Dakotas and Iowa, blackened the faces of World's Fair visitors in Chicago, and the next day, turned New York's sky yellow, its afternoon to dusk. "Much Awe Aroused by Phenomenon," headlined the *Journal* in Sioux City, Iowa, where the storm paled the eye of the bright afternoon sun until it shone as weird and blue as a foreign moon. The *Journal*'s page-one story opened with a quote from Revelation. Anything less seemed inappropriate.



The Bettmann Archive

The first European to set foot on the Plains was Coronado, following his vision of a kingdom of silver and gold. Wave after wave of Europeans followed. None was able to gaze upon the land and see it for what it was. Instead, like blind men, each discovered his own elephant. Early explorers in 1820 were convinced that they saw a wasteland. So strong was their vision that the first maps marked the Plains as the Great American Desert, and as late as 1859, Horace Greeley wrote, "I judge that the desert is steadily enlarging its borders and at the same time intensifying its barrenness." He proclaimed this land unfit for human habitation.

Indeed, anything short of Revelation would have been inappropriate, for the dust storms of the 1930s ended an era on the Plains. They put an end to the world of the independent farmer, a world based on a dream as reckless as the vision that drew miners, in 1849, across the prairie to the promised land beyond. The farmer's dream, like the gold miner's, was based on optimism and on an indifference to the land. The dust storms that blew this world apart were themselves the result of a long process of disintegration, a process that began the moment the first crop was sown on the flat grasslands. But in 1933 the end was not yet visible—for dust storms, although more dramatic than drought when viewed as individual phenomenon, actually extract their toll the same way: slowly, over the passage of time, like the embrace of a giant python whose coils tighten bit by bit.



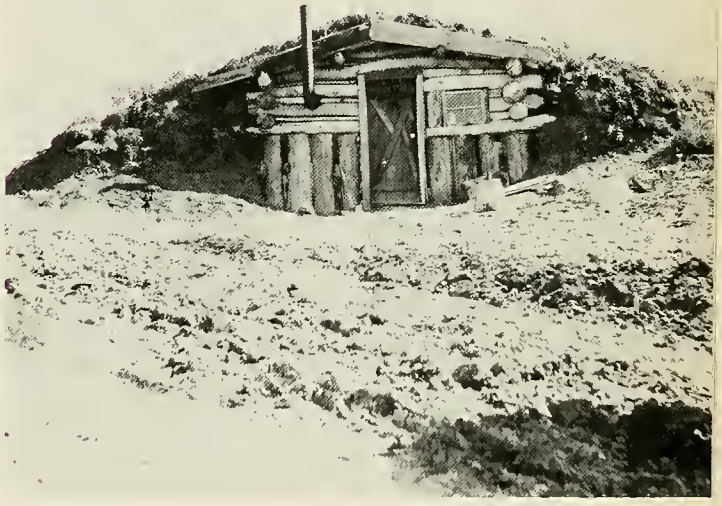
Gathering buffalo chips Culver Pictures

Those whose eyes were filled with dreams of fur or gold saw the Plains, as many still do, as a vast thoroughfare linking east and west. They beat a pathway through prairie grass high enough to cover the backs of their horses; their tracks can still be seen, running parallel with Interstate 80. The government, which fancied it could see the Plains clearly from its vantage point in Washington, envisioned the land laid out in modest European-sized farms of about 160 acres each. The Homestead Act, passed in 1862, made this vision official. Actually, the prairie was hardly comparable to any land in Europe; it was more like the great plains of China or Russia's vast steppes.

Shrewdest dreamer of all was the railroad, which saw nothing but coast-to-coast customers. In true American style, the railroad set out to market its dream, launching such an effective campaign that millions of farmers, looking for greener pastures, poured into the Plains. They came from states east of the Mississippi River and they came from Europe, particularly from Ireland, Germany, and Scandinavia. Between 1870 and 1900, more acres—some 430 million—were settled than during the country's entire previous history. The railroad worked this miracle by financing newpapers that printed glowing stories about opportunities on the prairie, the newsprint transforming every little hamlet into a burgeoning metropolis. Railroad agents, well supplied with newspapers and with exhibition cars displaying Plains produce, combed the east coast and the cities of Europe. Europeans willing to migrate were given steamship tickets and a free hitch on the railroad halfway across the continent to the Plains where, according to the agents, a husband waited for every woman, a thriving farm for every man.

When the settler arrived in his well-advertised Eden, he was greeted by old-timers who looked at his ax and scoffed, "A grass sickle will chop down all the trees where you're going." It was virtually true. The promised land was a shadeless plain, with not enough trees to build a fire, let alone a house, and with water scarcer than shade. The settler burned buffalo chips, built his house of sod, and nearly broke his back trying to till the promised land. True, he didn't have to fell a tree or move a boulder to clear his field, but the very soil itself resisted the plow. Indeed, it broke the fragile blade the European settler had brought with him. He had to resort to the John Deere plow in order to break sod; even then, it took five oxen to pull the steel blade through the ground and transform the flat land into farmland. The virgin prairie grass had root systems extending deep into the ground, searching the subsoil for moisture. The root network for each clump of grass totaled a mile or more. It wove, beneath the surface of the land, a web as thick and brown as a thrush's nest, a web that had for centuries knitted land and plant. The settler, in plowing, didn't simply break sod; he broke root—and in so doing, he began to break the land's defense system against the prairie wind.

The land, in turn, nearly broke the settler's dream. It didn't yield the way moist European soil did. Even 160 acres of choice land (and homesteading land was rarely choice) were not enough to support a man. The settler had to purchase decent land from the railroad or from real-estate promoters who bought land in large blocks, then resold it by the acre. As if that wasn't tribulation enough, there was always the weather, hardly paradisiacal. If hot sun and high wind didn't drive folks mad in summer, then winter blizzards would. Or hail. Or grasshopper plagues. Or prairie



Sod house Culver Pictures

fires. No wonder settlers left the Plains in droves, as many as 90 percent abandoning some areas. Signs on returning prairie schooners cryptically summed it up: "In God we trusted; in Kansas we busted." But despite afflictions, settlement crept steadily westward, following diminishing rainfall—about 32 inches annually at Dubuque, Iowa; 31 at Des Moines; 26 at Omaha. By the turn of the century, most land was occupied. East of the 98th meridian, which nearly splits the Plains in half, farmers tilled the land, harvesting "cash" crops of wheat and corn, gardening, raising chickens and hogs, and grazing cattle, for American farming was still diversified in the European fashion—a realization of the government's dream. To the west of the 98th meridian, where annual precipitation of about 20 inches makes farming unprofitable, ranchers grazed cattle and cursed the farmer who, they maintained, was the ruin of the country, having "everlastingly, eternally, now and forever, destroyed the best grazing land in the world."

Meanwhile the settler's dream, weakened but not abandoned, was unexpectedly shored up by a new dream forming in the industrial east, a sophisticated belief in progress. Progress, after all, rested not on myth but on an inviolable law of nature. It was scientific. Darwin's *Origin of Species* began to assume an authority once claimed only by the Bible, and lo, the ancient dream of Eden began to transform itself into an optimistic vision of a utopian future based on science and technology, a new civilization whose unfolding was as inevitable as man's evolution from the apes.

World War I rapidly advanced this dream. "Wheat will win the war," the government proclaimed when the beastly Hun blockaded the Dardanelles, cutting Europe off from her Russian wheat basket, "Plant wheat!" The marketplace echoed the cry, and wheat prices jumped, from a prewar level of 60 to 80 cents a bushel to $1.00, then to $1.40, and kept rising. By 1917, when the United States entered the war, wheat had broken $2.00, the highest price the farmer had ever received. It went up to $2.10 and held. As the market boomed, the industrialist—smelling profit—took time off from developing tanks to do for the tractor what Henry Ford had done for the automobile: turn it from a novelty to a necessity. When salesmen showed the farmer how, if he replaced his team of horses with a fuel-powered tractor, he could plant as much as he could plow, the farmer didn't need much convincing. The number of cultivated acres doubled during the war as tractors rolled onto the Plains by the thousands. More than 11,000,000 acres—twice the land area of Massachusetts—was land that had been plowed for the first time. In Kansas alone, wheat acreage increased from 4,870,000 acres in 1910 to nearly 12,000,000 in 1919. Even the weather cooperated. Plentiful rainfall, combined with patriotism, profits, and technology, created an era of prosperity such as the farmer had never known.

The end of the war should have collapsed the market and the dream of progress, but it did not. Instead, the government guaranteed wheat prices as part of its relief to Europe. And, by the time Europe had recovered, the industrialist had come up with a new technological miracle, the combine. This marvelous new machine, which cut, threshed, and cleaned the grain, released the farmer from his dependence on the hired hand in exactly the same way that the tractor had released him from his dependence on the horse. The ceiling went off wheat production; the age of



Combine at work in wheat field

Culver Pictures

Nebraska State Historical Society



Heavily eroded field

"wheat kings" began. Between 1925 and 1930, the amount of cultivated land jumped by 34 percent. With the combine, the farmer could reap as much as he could plant. With the tractor, he could plant as much as he could plow. With both, a bushel of wheat took only three minutes of human labor to produce. There was one drawback, however: it took a lot of land to make a combine pay. But the industrialist offered easy terms, and the banker volunteered to mortgage farmland. Never a slacker, the farmer borrowed, bought land, and began to plow up everything he could. First he plowed farmland; then he plowed pasture, planting wheat everywhere and leaving fields bare from the time of sowing to the sprouting of the seed. Winter wheat was the worst. Sown in the fall, it left fields bare to the wind all winter long. When the farmer ran out of land on the rainy eastern half of the 98th meridian, he crossed right over and plowed semiarid ranchland, gambling on rain as he replaced long-rooted prairie grass with short-rooted wheat. By the time he finished sowing, the only thing that remained to bind dirt to land was moisture. So blinded was he by his dream that he even tilled land whose topsoil was so thin that the Plains clay, caliche, lay just below the bite of the plow. The sky was the limit, as far as the farmer was concerned. It never occurred to him that the land might have a limit, too.

The farmer, busy sowing wheat and reaping gold, could foresee no end to his land of milk and honey. Never had his dream seemed more real. Progress was visible everywhere: in radio waves that brought New York to his living room; in automatic planters that seeded his crops; in towering silos made of gleaming concrete; in cars and trucks zipping up and down the roadways, streamlined trains tearing across the continent, and planes bucking air currents on a new frontier.

Then, in the summer of 1930, drought hit. Precipitation east of the Rockies was 500 billion tons short of normal, the worst drought on record, the weather bureau said. It lifted in 1931, dropped again in 1932, and by 1934 looked likely to run forever. The hot eye of the sun began to evaporate the land's final protection against the wind—moisture. Lakes dried to puddles, and the water table under the Plains, which feeds the area's wells, lowered perceptibly. In Nebraska, where I was born, the Platte River was nothing but one long sand bar cutting across the state. That was hardly unusual (hadn't Artemus Ward called the Platte "a good river if you set it on edge"?), but sand bars in the Mississippi River were disconcerting. The Mississippi dropped to an all-time low, 2.5 feet below its previous low-water mark of 1864, so shallow in spots that swimmers could walk across it.

Still, the farmer was hardly alone in his lack of foresight. When in 1933 a thunderhead dropped red dirt mixed with rain, an imaginative Nebraska newsman wrote: "Omaha was blanketed with thick, red volcanic dust early this morning. It is believed to have been carried from volcanic eruptions in the Aleutian Islands several weeks ago." A University of Nebraska geology professor, E. E. Schramm, was more realistic. When he analyzed the dust (gypsum, volcanic ash, silt particles), he concluded that it orginated in the red Permian beds of Kansas, Oklahoma, and Texas, beds formed late in the Paleozoic Era (before the rise of the

Nebraska State Historical Society



Cut cornfield losing topsoil



Approaching dust storm



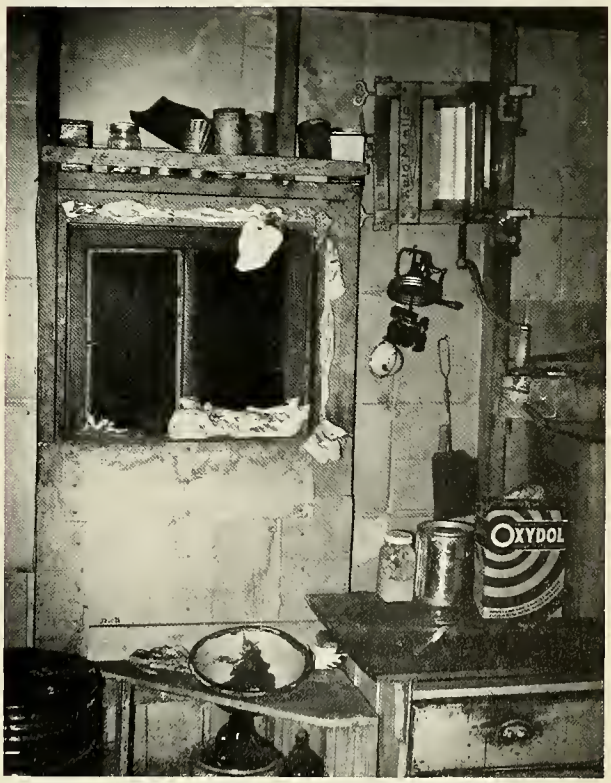
Nebraska State Historical Society

dinosaur) and now, some 250 million years later, transported by wind to Nebraska. Yet even Professor Schramm was unwilling to see what this might mean. Instead, he considered the deposit a windfall: hadn't Nebraska farmers just received $25 million worth of free fertilizer?

But blind optimism was not confined to the Plains. When the first great dust storm reached the east coast in November 1933, the *New York Times* was quick to assure readers there was no need to worry. Such storms, wrote its science writer, were similar to the red sirocco storms, which blow from the Sahara Desert across the Mediterranean to southern Europe and sometimes combine with rain, forming "showers of blood" that can strike terror in the hearts of "superstitious peasants." These "displays" were nothing compared to the record dustfall of March 1901, a series of cyclones that dropped some 550 million tons of dust over much of North Africa, the Mediterranean, and western Europe. In turn, this was peanuts beside the volcanic eruption of Krakatoa, which shot dust 50 miles into the air, turned skies red for three days over much of the world's surface, and rained dust around the globe for years. Now that was a dustfall!

These "blood rains" were regarded as "freaks of nature," weird combinations of circumstances that couldn't possibly be repeated in a hundred years. And, in truth, there was something fantastic about a dust cloud that covered 1,350,000 square miles, stood three miles high, and stretched from Canada to Texas, from Montana to Ohio—a cloud so colossal it obliterated the sky. Just as there was something

Russell Lee, FSA



Rags stuffed around windows to keep out dust

Arthur Rothstein, FSA



Stripped trees rise from dust dunes

preternatural about a dust cloud dense enough to eclipse the sun simultaneously in six states. Or about New Mexico's soil turning New England's snow yellow. Or about a four-day storm in May 1934 that transported some 300 million tons of dirt 1,500 miles, darkened New York, Baltimore, and Washington for five hours, and dropped dust not only on the President's desk in the White House but also on the decks of ships some 300 miles out in the Atlantic. Who could believe such things?

Certainly not the farmer. After each storm, he paused to curse his bad luck, then revved up his tractor and replanted his crop. A man of dreams, the farmer was, a man of fierce determination. He had to replant. He owed the banker so much, it was reap wheat or lose his farm, so he ignored the county agent's warnings against "reckless sodbusting," as they'd been ignored since the late 1800s. And he paid no attention to the government that begged him to stop plowing, that had beseeched him, since 1929, to reduce his wheat acreage. Why should he listen? Government subsidy, even under the Hoover administration, had kept the wheat market from foundering. Instead, the farmer plowed like a man determined to make a silk purse out of a sow's ear, no matter what the price. He refused to believe that he was laboring only for the wind. But he was. Each turning of the earth only further pulverized the soil, leaving it more likely to blow. Topsoil, cream of the earth, went first. When the wind came in, hugging the ground, dry dust rose like a mist, skimmed over the land—cutting from one field to another until both surfaces were moving. Not just earth went. So did humus, separated from the soil by the wind; so did seed, blown out of the furrows, and small plants, lifted bodily into the air. Little remained grounded, finally, but barren soil—and the roots of growing grain, which would soon wither and die. The more conscientious the farmer had been, the more he pulverized the soil in plowing, the greater his loss.

The more the dust blew, the finer it became, grinding itself into smaller and smaller particles until it hung in the air like motes in a sunbeam. Dust blew everywhere, penetrating even closed houses, rippling on window sills, clinging to walls and curtains. Nothing could shut it out. The housewife tried. She stuffed oiled rags around windows and doors. When that didn't work, she sealed cracks with packing tape; when that didn't work, she hung bedsheets and sprayed them with water or kerosene. But nothing worked. Food laid out for supper would be ruined, the milk turned black in the glass. Everything—beds, clothes in the closet, food in the refrigerator—was covered with a fine film. "It takes grit to live in this country," joked the farmer, but few laughed as masses of dust began to billow into huge tumbling clouds, ebony-black at the base and muddy tan at the top, some so saturated with dust particles that ducks and geese, caught in flight, suffocated; some turning the sky so black that chickens, thinking it night, would roost.

The storms were not perpetual, but they began to seem that way. "There is rarely a day when at some time dust clouds do not roll over," wrote Caroline Henderson, an Oklahoma farm woman, for the *Atlantic Monthly*. Oklahoma counted 102 storms in the span of one year; North Dakota reported 300 in eight months' time. Most arrived early in the day and lasted until nightfall, but some raged through the night, and a few blew for days. The devastation wreaked by these "black blizzards" was astounding. Some 300,000 square miles—four times the land area of Nebraska—were damaged by dust or erosion. The

Dorothea Lange, FSA



Drought victims on the road to California

government estimated that 850,000,000 tons of soil were being swept off the Plains each year, leaving some 150,000 square miles of land devoid of topsoil, bleak stretches of ground that lay totally barren beneath the wind. After the blizzards, people crept from houses or storm cellars to view a world increasingly transformed. Dead rabbits and birds littered the fields; once-green gardens and pastures lay beneath carpets of dust so fine that shoes left tracks as though in snow. Landmarks disappeared; plum thickets died out; even groves of locust trees vanished. Anything that slowed the wind—a tractor, a tumbleweed caught in barbed wire—would have a drift behind it. Dirt covered fence lines until only scattered post tops remained visible. It drifted as high as the eaves of houses, blocked roads and railroad tracks so badly that snowplows had to clear them.

Lackluster cattle, which had fed on weeds, then on thistles, finally on nothing, stood gaunt and listless—their hides rough, ugly growths festering around their mouths. Some farmers offered livestock, free, to anyone who could feed them. One man in Minnesota shot twenty-two head of cattle, then shot himself. Outlined against the sky, summer trees stood naked as skeletons, while farmhouses seemed like strange summer cottages dotted along wind-rippled dunes of dust on a vacated beach. Except for the savage grandeur of the wind, it was a silent and desolate world. Most of the wildlife that hadn't been killed had already migrated.

Men followed suit. By 1935, thousands of dry-land farmers were streaming out of the Plains in a great exodus to California that would be memorialized later by John Steinbeck. During the decade of the thirties every state in the Union gained in population except five: the Dakotas, Nebraska, Kansas, and Oklahoma. Those states lost more than 300,000 people; most of them left in 1935 and 1936. Some folks—desperate, stubborn, or held tenaciously to the land by hope—stayed. Crop failure followed crop failure until life seemed as Biblical as Revelation (9:12): "One woe is past and, behold, there came two woes more hereafter." Fields were badly eroded; some had lost topsoil as deep as the land had been plowed. The remaining subsoil or, in some cases, clay was not porous enough to retain moisture or rich enough to support plants. Many, including the government, feared that the Great Plains had become the Great American Desert that early explorers thought it was. Pasture after pasture was destitute of grass; cornfield after cornfield yielded nothing but dead stalks. "I don't think I picked ten bushels of corn from 320 acres," said Roy Glandt of a Nebraska crop. The land itself had lost its capacity to sustain life. The ocean of prairie grass that had been tamed into amber waves of grain became, in a few years, a wasteland. Finally, even the farmer's optimism crumbled into despair. "We drive as if going to a funeral," wrote Meridel Le Sueur of this period. "The corpse is the very earth."

And so it was. The dream of progress had proved to be, not an alchemy, but a black magic that had all but exterminated the land. Progress, with its technology,

Dorothea Lange, FSA



The new agricultural migrants

its profit motive, and its indifference to nature, had reduced paradise to a darkling plain. No longer could anyone believe that the earth would, necessarily, abide forever. That the land would, unconditionally, remain part of the land. No longer could man believe in his dominion. The shock was understandably extreme: it was the shock of the infant discovering the breast is not his. The lesson was a bitter one.

The long task of reclaiming the land began; the government took most of the initiative. "Plant trees," said the government, and thousands of trees were planted as windbreakers. "Dig ponds," said the government, and ponds were dug. Snow fences were put up to slow wind erosion, dirt-filled burlap bags were piled on top of dunes, and emergency cover crops were sown. The government purchased some two

John Vachon, FSA



Farm wife watches as her belongings are auctioned

million acres (including 220,000 abandoned farms) and planted them with native grasses, permanently retiring much of the land from agricultural use. The reclamation process took four years, even with the help of rain. But eventually the Plains healed, and crops grew again. Not that the land would ever be the same. Topsoil, once blown away, can never be returned; virgin prairie, once plowed, can never be reclaimed. But gardens sprouted, lilacs and roses bloomed, and wildlife returned.

The dust storms had not been apocalyptic in a physical sense, but in another sense they were. We who were born, as I was, at the end of the thirties, were born into a new era. The farmer was gone. He had been replaced by the agronomist, a scientist of soil management who was concerned with regulating, not conquering, nature; who worked closely with the engineer to conserve the precious resources of the Plains. The agronomist, of course, believed in the survival of the fittest, but he was not as cocky as the farmer had been, not as certain that man was destined to win that particular fray. In this new world, man and nature hung in a delicate balance. Accordingly, in the classrooms of the forties, I was taught (alongside the farm boys) the lessons of the thirties: how to reduce wind erosion by strip farming and crop rotation; how to plow at right angles to the prevailing winds; how to conserve moisture by stubble mulching and by keeping a cover crop on dry land. We were taught a new respect for the ancient arts of terracing and contour farming, a new respect for the land. "He who is prudent in his use of the land," we were told, "will suffer only heavy losses during the cycles of drought, but he who is improvident will suffer disaster." Clearly the sins of our fathers were not to be repeated.

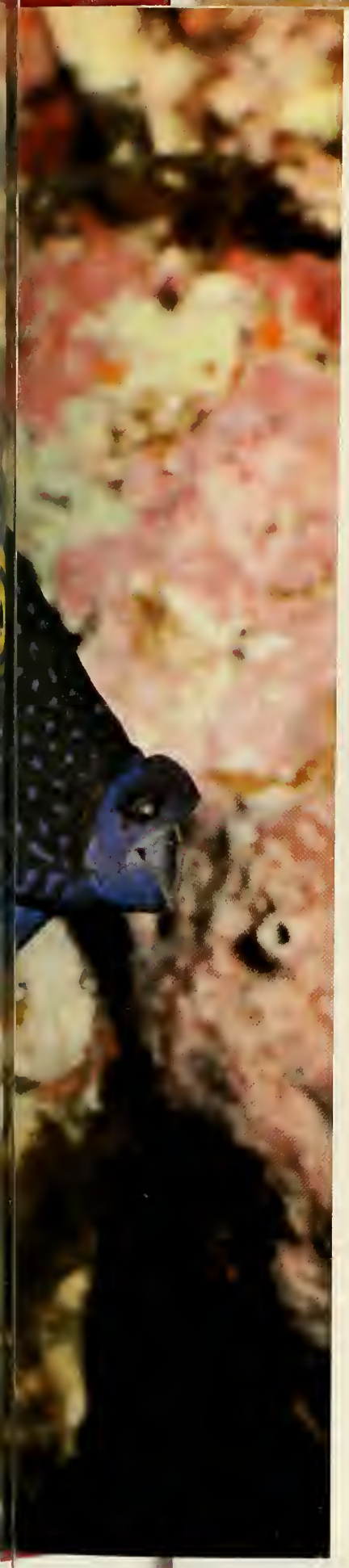
Outside the classroom, I watched these lessons being driven home as a huge dam was built on the Republican River, which cuts across Nebraska south of the Platte, a dam designed to retain the water that flows across the Plains from the Rocky Mountains, water that could irrigate the crops during the inevitable seasons of drought. It was part of a vast system of dams being carved into the Plains. The age of reckless and fickle optimism was clearly over. The world that had begun the moment the settler had arrived on the Plains with his plow and his wagonload of dreams was gone. The dust storms had blown that world away as surely as they had dispersed the topsoil, as surely as the wind had toppled the hardy independence of the farmer and eroded his dream. Not even the energy of World War II could bring it back. It was history, buried with the buffalo. The sky, the enormous Gothic sky, still arched overhead, and underfoot the land stretched out, or so it seemed, from sea to sea. But that, we knew, was an illusion. The sky might be limitless, but the earth was not. □

Marion Wolcott, FSA

Strip plowing, a safeguard against eros







The Ornamental Eye

by Ronald E. Thresher

Many reef fishes have conspicuous eyes, the better to communicate with

Brilliant colors are the visual hallmark of a coral reef. Purple and red shrimps peer from orange- and green-lined crevices in the coral; bright red sponges and purple and green gorgonians dot the seascape. But by far the most spectacular colors are found on the fishes. Black-and-yellow-banded angelfish swim slowly through swarms of electric blue damselfish, and scarlet-spotted hawkfish scoot about the coral. A colorful kaleidoscope of spots, stripes, swirls. and bands shimmers and flashes as the reefs' piscine inhabitants search for food, shelter, and mates. These striking and sometimes bizarre color patterns have perplexed and impressed scientists the world over.

Despite this interest, the function of such color patterns is still poorly understood. The consensus, however, is that in many species brilliant coloration serves as a means of communication. For example, various "cleaner fish," which must advertise their presence to potential customers in need of parasite removal, are invariably brightly colored. In some species, conspicuous, or "poster," coloration coordinates group activities; in others, it warns intruders away from an area already claimed by a territorial fish. Such examples of advertising demonstrate the importance of color—and vision—to reef fishes. This reliance on visual cues is related to the environment of a reef.

In the often crystal clear waters around a reef, visual cues are detectable at a distance of many feet, thus enabling a signaler to be accurately located and identified. Chemical cues, on the other hand, are rapidly dispersed on the reef and may even be washed away by currents and tidal surges. Similarly, sounds are often difficult to localize and are easily drowned out by the crash of waves and the myriad noises of the reefs' other inhabitants. Under such circumstances, coloration is the most effective way of gaining and transmitting information.

Because of this reliance on visual cues, most reef fishes have large, well-developed eyes and react to the slightest movement near them. Possession of such eyes, however, is a mixed blessing. Although they permit an effective view of the environment, large eyes also pose a special problem for an animal when it needs to conceal its presence. The otherwise effective camouflage both of predators, hiding in wait for prey, and prey, hiding from predators, could easily be ruined by a large, circular, glistening eye. As a consequence, numerous fishes have evolved complex adaptations to disguise their sight organs. Some have uniformly colored eyes that match surrounding head colors and, thereby, seemingly disappear; others have one or more lines running through their eyes, breaking up their outline and making them less obvious. A few species confuse by having many "eyes": two real ones; the rest,

Outlining is the most common form of eye ornamentation among the reef fishes studied. This kole, native to Hawaiian waters, has three rings around its pupil.

Z. Leszozynski, Animals, Animals

Douglas Faulkner



eyelike spots scattered about the body. The evolution and function of such adaptations have been widely studied and discussed by many scientists.

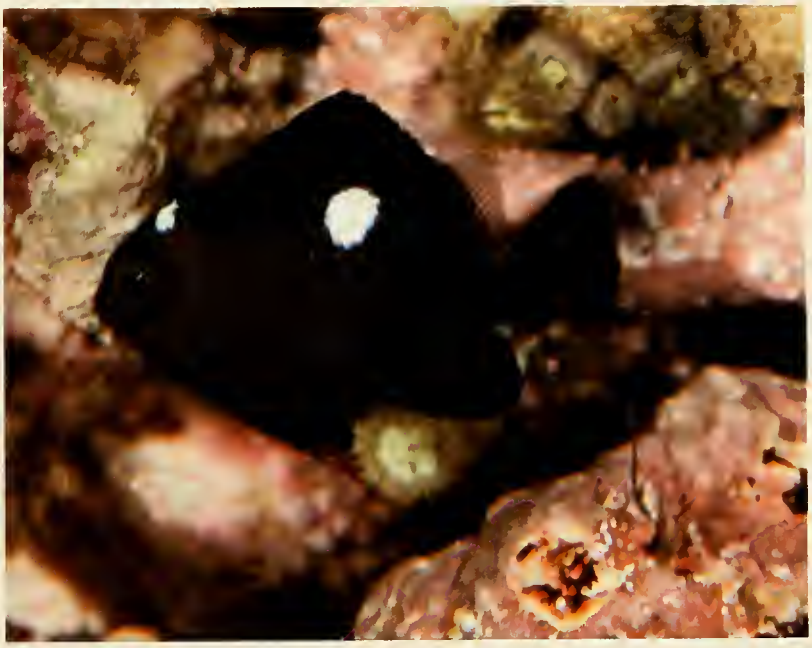
My observations of eye-color patterns in reef fishes of the tropical western Atlantic, however, have led me to conclude that for many species the association of color and eyes has evolved in another, completely different direction. I closely observed eighty-five species of common reef fishes, including carnivores and herbivores, free-swimming and benthic types, brightly colored ones as well as those with subdued or even cryptic colors. I found that many species had prominent and often wildly ornamented eyes; in fact, less than 25 percent of the species had camouflaged eyes. The prevalence of conspicuous eyes was remarkable, as were the patterns of their ornamentation and their color combinations.

The most frequently encountered form of eye ornamentation was outlining. Putting an outline around an object is one of the most effective ways to make it conspicuous, just as disrupting its outline is an effective form of concealment. The eye, especially when round, lends itself well to outlining. This is largely achieved through color variation or shading of the pupil, iris, and surrounding head area. Typically, the pupil, iris, and surrounding head area are all differently colored, creating a "bullseye" effect that focuses attention on the pupil. A few fishes carry this even further with additional full or partial rings of alternating colors around their eyes. In its most extreme form, the angelfish *Pomacanthus paru* has four such rings around its pupils.

Another common adaptation that makes the eyes prominent is contrast. For a color signal to be most conspicuous, brightness contrast and simultaneous color contrast must be maximized. Brightness contrast entails the combination of a dark, nonreflecting area immediately adjacent to a bright, shiny one; the sudden change in brightness draws attention and the sharp boundary enhances outlining. Simultaneous color contrast is a balancing act of sorts that caters to the recipient's visual capacity to receive a signal. The ideal color signal is one to which the recipient

Animals, Animals







The emperor angelfish, above, and a domino damselfish, top right, have camouflaged eyes. A variation is the eye of the copperband butterfly fish, right, whose outline is disrupted by a colored band. But the eyespot on its fin is conspicuous because of size, outlining, and color scheme.

is most sensitive; on the other hand, the use of two colors creates an attention-drawing contrast. The farther apart the two colors are spectrally (and thus the farther from the point of peak sensitivity), the more dramatic and effective the contrast. The optimum balance be-

Z. Leszozynski; Animals, Animals

tween opposing selective pressures is the use of two colors whose combination minimizes signal loss due to a shift away from peak sensitivity, while maximizing their spectral differences. Based on the spectral sensitivities of reef fishes, the juxtaposition of blue and yellow should strike the most effective balance.

Both brightness and simultaneous color contrast are manifested by reef fishes. Virtually all fishes with conspicuous eyes have a dark pupil outlined by a bright iris. Moreover, the pupil is often dark blue; the iris, bright yellow. In fact, blue, yellow, and for additional contrast, black are found in one or another combination in the eyes of more than half the fishes on the reef. Fishes as far apart systematically as gobies and jawfish have converged toward this particular combination of eye color.

The blue tang, *Acanthurus coeruleus*, provides an impressive example of selection for such colors. As a juvenile, the fish is bright yellow, but as it matures, its body gradually turns pale blue. Throughout this change, its pupil is deep black, surrounded by a two-color iris. Between the pupil and the mostly iridescent blue iris, is a fine yellow outline. In its yellow phase, the tang's eyes are conspicuous black and blue spots on a yellow body, thus the three-color combination; as the fish matures, the eyes' outer blue ring merges with the newly developing body color and the fine inner ring manifests itself. The eyes are now black and yellow on a blue background, as conspicuous as they were earlier and still retaining the basic three-color motif.

These same three colors show up over and over again on reef fishes wherever the need for a conspicuous visual signal has arisen. Most of the cleaner species, such as the Spanish hogfish and the neon goby have body-color combinations of blue, yellow, and/or black. Several territorial fishes, such as many damselfish, are entirely blue and yellow. The false eyes on several juvenile damselfish are black, outlined with blue, on a yellow background. The same colors are featured in the large spots found on the snouts of many hamlets, small predatory basses common on the reef. Hamlets are a polychromatic group, and their conspicuous nasal spots may have evolved to provide a standard for species recognition.

The reasons for the evolution of the eyes of most reef fishes as conspicuous signals are not completely clear. To a large extent, it reflects the importance of the eyes as a means of short-distance communication throughout the animal kingdom. Even in humans, glaring at people carries a different meaning than refusing to look them straight in the eye. For many mammals, birds, and fishes the eyes are a key stimulus, which releases and orients

Reef fishes can best see blue and yellow. A combination of these colors, with black for added contrast, is common in species that depend on visual signals, such as the (juvenile) yellowtail damselfish, below. The mandarin fish, right, has a number of lines that serve to break up the outline of its eyes.



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Animals, Animals

behavior. The Siamese fighting fish, for example, will display to and attack a shapeless lump of clay so long as it has a pair of distinct "eyes." Recent research on Hawaiian damselfish showed that their eyes are an important means of communication during aggressive interactions. During a fight, not only the relative strengths of two combatants but even the eventual outcome can be determined by watching the changing color patterns around their eyes. As the behavior of reef fishes is studied in greater detail, conspicuous eyes probably will be shown to play important roles in courtship, spawning, schooling, and virtually all other social interactions.

But as important as ornamented eyes may be in short-range communication, fishes with such eyes should theoretically have to pay the price of conspicuousness. Most animals cannot afford to have permanently bright colors around their eyes because predators could key in on these prominent features.

If this is true for other animals, why should reef fishes be free of such constraints, especially since predators abound on the reef? The answer is twofold. First, the reef is riddled with hiding places for small fishes, which the larger predators cannot enter. Holes, crevices, and caves are never far away, and a threatened fish can quickly find cover. Such protection lessens the need to remain unobtrusive and cryptically colored. A second factor concerns the relative visual capabilities of prey and predator. Most reef fishes have eyes that are adapted to seeing best during full daylight conditions, when they are active. Predators are most active at dawn and dusk and their eyes have evolved to be most sensitive during these periods of dim light. So during the day, the predators are at a disadvantage. A grouper is seen by potential prey long before it can see them.

These two factors largely account for the limited amount of predation on small reef fishes during the day. Their color patterns, including those involving the eyes, are free to respond to other selective pressures, such as the need for effective short-distance communication. In the long run, this relative freedom from predation may well prove to be the single most important factor in understanding the significance of the rainbow colors of coral reef fishes. □



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Notes from a Pioneer

LETTERS FROM THE FIELD, by Margaret Mead. *Harper & Row, $12.95; 343 pp., illus.*

Most of the letters in this volume were written, not to a particular individual, but to a varied, known, and loved group of people. And such is their straightforward style and eloquence that a reader, in some magical fashion, finds herself or himself taking, not the role of a student or critic, but the role of a friend or sympathetic colleague. To read letters from a friend in the field when that friend is Margaret Mead is a unique experience.

There are field letters from Samoa, Manus, the Omaha Reservation, New Guinea, Bali, and Iatmul, from a second visit to Manus, and from many subsequent, shorter trips. The time span extends from 1925 to 1975, and each of the major field expeditions is prefaced by an introduction explaining the relevant personal, academic, and scientific circumstances. As a bonus, the volume opens with the most illuminating and helpful short statement about the importance of fieldwork that I have ever read.

Mead's vivid and uninhibited descriptions of what she sees and



Gregory Bateson

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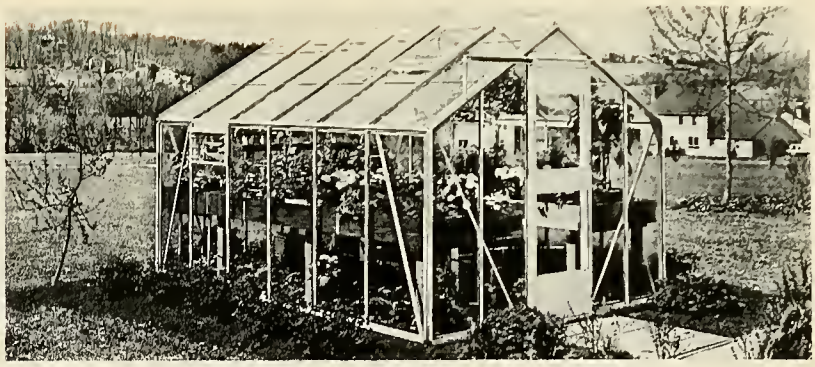
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by Rosalie H. Wax

what she does are, in turn, moving, amusing, horrifying, and awe inspiring: the death of a native child in Manus; the trickster fashion in which she and Gregory Bateson are blackmailed in Bali by the assistant chief priest of the village; the remarkable pigs at Alitoa who, if no children or dogs are within reach, are petted and take on the behavior of dogs; her irate expressions of dislike for the white residents who are ruthlessly exploiting the country and the native peoples; the courage and efficiency with which she copes with a hurricane in Samoa in 1926 and a volcanic eruption on her return to Manus in 1953; her description of the effect of prolonged isolation and disassociation from the outside world—with no mail for three months, no radio, nothing to read, her watch broken, and both she and her husband ill—"I even begin to wonder what date it is."

The letters from Samoa are, for me, particularly appealing. On her own choice and initiative, this young and inexperienced woman, "with the courage of almost complete ignorance," traveled halfway around the world to study adolescent girls in "a remote and untouched place." The good sense and judgment she employs in arranging her living and working situations so that she can do what she came to do; the diplomatic skill with which she accepts, and also evades, the handicap of high status bestowed on her by the Samoans; the fearlessness with which she lives through the hurricane (while caring for an infant and a small child) elicit from me the response: "Would that my students should do as well on their first field trip."

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A MARVELOUS GIFT FOR A SCIENCE-MINDED FRIEND!

Cante ohitika win ("brave-hearted woman")! Truly, as she says in her autobiography, *Blackberry Winter*, she had the sense "of being invulnerable as long as I was moving in the right direction." Her detailed accounts of the elaborate and time-consuming obligations of rank, the intricate social maneuvers by which she compensated aristocratic informants, the seemingly endless gifts and personal favors extracted from her by old and young make it difficult to sympathize with those anthropologists who have denounced their colleagues as "exploiters of the natives." Speaking for myself, and construing exchange reciprocities strictly, I have come out on the short end of almost all my transactions with the people I studied; although the intangible benefits have been great, these have not been acquired at their expense but rather in mutual benefit. Fieldwork is not a zero-sum game.

With the present-day emphasis on women's studies and women's liberation, it is well that we are reminded that Mead initiated the comparative study of women (and children) in other cultures more than 50 years ago, and that she has probably done more research on women and contributed more factual and insightful information about them than any other anthropologist—and, perhaps, any other human being. And, given her independence and originality, it is not surprising to learn that, on occasion, female critics have accused her of antifeminism, whereas male critics have accused her of rampant feminism. Her views about men, women, and children are, of course, best revealed in her own words. From her autobiography:

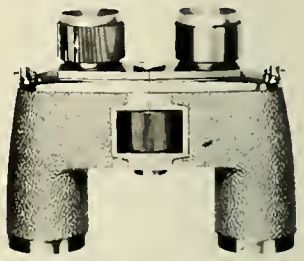
Because of their agelong training in human relations—for that is what feminine intuition really is—women have a special contribution to make to any enterprise, and I feel it is up to them to contribute the kinds of awareness that relatively few men—except, for example, child analysts or men who have been intimately reared by women—have incorporated through their education.

From the letters, Alitoa, 1932:

The emphasis upon sex difference begins in the cradle—baby girls are decked out in earrings and necklaces, while boys wear no ornaments until almost grown. Little girls of four and five strut and flirt. The women do all



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the carrying, the weeding, the cooking and have to all appearances a hard life, but they are attractive, valued and conscious of being valued. Shut out from the religion, from magic and from the social life of the men, they nevertheless seem to maintain a firm sense of importance, and it is a sight to see a young woman swish her way across a village square where all the elders have been orating vigorously upon some affair of state.

Mead, Ann Fischer, and I are in emphatic agreement that most field situations require the combined and cooperative effort of a man and a woman. In her book on the Omaha, *The Changing Culture of an Indian Tribe*, Mead notes how much easier it is for a woman to talk to the women than for a man to talk to the men, and she reiterates it in a letter from the Tchambuli, dated 1933: "Like most of New Guinea, the men's houses and the religious cults make for a sharp division between men and women, and it is therefore ideal for a man and a woman to work together in this culture."

It is of historical interest that Edward B. Tylor said much the same thing in 1884 when advising American anthropologists on how to approach the study of American Indians. If a man and wife work together, he said, "half of the investigation seems to fall to her, so much is to be learned through the women of the tribe which the men will not readily disclose." Anthropologists, Tylor continued, ought not to sound the bull-roarer and "warn the ladies off from their proceedings, but rather to avail themselves thankfully of their help."

My husband and I came to an identical conclusion while we were carrying out our study of education among the Sioux on the Pine Ridge Reservation in 1962/63. We found that the task demanded not only the cooperative work of a mature woman and a mature man but also the assistance of several younger people who, in this case, were American Indians. But Mead anticipated us in working in the field with young people, having returned to Manus in 1953 with Theodore and Lenora Schwartz. As she herself puts it: "Any team, of whatever composition, but especially one contrasted in sex or age, will be able to do, not twice, but four or five

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times as much work as one person working alone."

This volume of letters also demonstrates that Mead was one of the first anthropologists who wanted to study cultural change. Unhappily such was the definition of field research that she spent almost three decades collecting data on peoples who, it was hoped, had undergone little change. Then in 1953, the opportunity to study change was thrust upon her, for on her return to Manus, she found the people in the midst of a self-initiated revitalization movement. They told her: "We have decided to have a new way of life, to throw away every evil custom of the past and set up our own form of life." Here is how she describes her reaction to this unanticipated field situation:

I am fascinated with the type of commitment which I find I have to the accomplishment of their aspirations. I am not sure what it is, a reflection of a change in the whole climate of opinion in the world, or an accidental temperamental congruence, so that I feel closer to a people who believe that they can remake their culture if only they have the will to do so, or simply the human sympathy one feels for people whom one has known most of their lives. . . . In 1953 we are committed to mobility within one generation and to building a world where the valuable unit is a human being and not simply membership in one kind of culture rather than another. And this means we cannot afford the aesthetic nostalgia for a "whole culture" and "cultural depth," because we can only win this temporary battle with time by putting ourselves back of human aspirations, aroused by ideas of medicine, science, literacy and human dignity. . . . I had not guessed that there would be a sort of spiritual change which would be so gentle and so moving. It has the same sort of appeal that the first songs of a revolution have, but this has been a bloodless revolution without violence of any sort and within the law—without any change in government in the larger sense but with this tremendous increase in local organization and autonomy. The children are . . . more delightful than they were 25 years ago. . . . It's all very good.

Today, half a century after Mead first went into the field, it is tragic to observe the multiple and conflicting restrictions being placed upon the practice of fieldwork. An increasing number of nations have decided that they cannot permit the

Please turn to page 98

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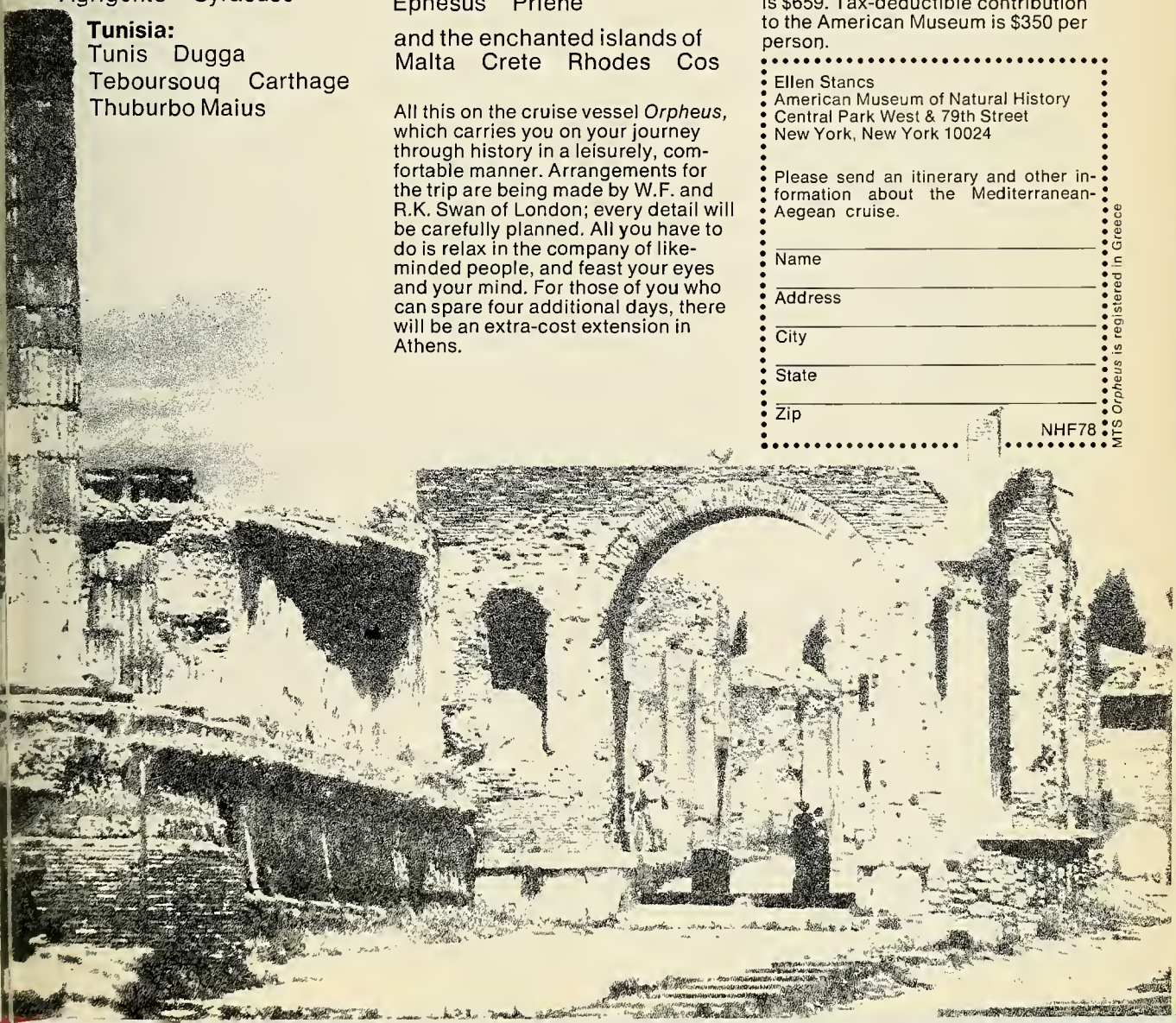
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THE RULES

1. The competition is open to everyone except employees of the American Museum of Natural History and their kin.

2. Competitors may submit up to three previously unpublished entries in each of the four categories. Decision of the judges is final.

3. The Museum acquires the right to publish and exhibit the winning photographs and to use them for promotional purposes. The Museum assumes no responsibility for other entries.

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independent and dispassionate study of their peoples and institutions, despite the clear evidence of the multiplicity of benefits that such studies have conferred upon humankind, revolutionizing our thinking about sex roles, ethnic differences, dietary habits, health, medicine, and social change. Meanwhile, in response to perilous biomedical experimentations, the United States government has forced universities and related institutions to protect human subjects from the broadest range of research activities, including those of fieldworkers, and thereby has required investigators to state precisely beforehand where, with whom, and with which procedures he (or she) will be working, while obtaining beforehand the signatures of their "subjects" to a document of "informed consent." So hampered, Mead could scarcely have accomplished her great series of field investigations, and she has contended that anthropologists use no "subjects" but instead work cooperatively with informants and native colleagues. Unhappily, neither her voice nor that of sympathetic colleagues has been of influence upon federal policy makers. Further complicating the issue has been the heritage of United States involvement in the strife in Southeast Asia. Via their professional association, American anthropologists have imposed upon themselves a politico-ethical code that would, if realistically followed, convert investigators into saintly idiots, without noticeably benefiting the peoples among whom they are working. It is greatly to Mead's credit that, at the height of this witchhunt within the American Anthropological Association, she spoke for sanity, tolerance, a respect for all peoples, and a concern for the human and scientific values of fieldwork. This volume of letters helps us to appreciate her abilities and her moral courage.

Rosalie Wax is professor of anthropology at Washington University in Saint Louis. She has done fieldwork among the Japanese-Americans confined during World War II, and with her husband, Murray Wax, among the Oglala Sioux. Wax is the author of Doing Fieldwork: Warnings and Advice.

In Pursuit of Birds

by Michael Harwood

THE AUDUBON SOCIETY FIELD GUIDE TO NORTH AMERICAN BIRDS. 2 Vols. EASTERN REGION, by John Bull and John Farrand, Jr. WESTERN REGION, by Miklos D. F. Udvardy. *Alfred A. Knopf, $7.95 each; 775 pp., 855 pp., illus.*

When North American field birding became a sport, as an antithesis to no-birds-barred gunning, a demand was created for pocket field guides to help the ordinary nature lover tell one feathered friend from another. The sport sprang from the scientific community's concern about diminishing numbers of birds, so the field guide art form came from a scientific background. Its first major expression, Frank M. Chapman's *Handbook of Birds of Eastern North America* (originally published in 1895), introduced the neophyte to the science, as well as the pleasure, of bird watching. But over the years the approach has changed considerably. Most field birders are not interested in sorting through complex details in order to identify birds. Is it or isn't it? that is the question. The current best handbook for these birders was introduced in 1966: *The Birds of North America,* by Chandler S. Robbins, Bertel Bruun, and Herbert S. Zim. It improved on the previous "birder's bible," the Roger Tory Peterson field guides (still very much in use), chiefly by putting the text and pictures for individual species opposite each other on two-page spreads, so that the birder in the field didn't have to spend a lot of time flipping pages between text and pictures while the bird flew off.

In this process of amateurization of the field-birding literature, however, the major field guides have continued to follow the accepted scientific order of birds in presenting them. The order *is* logical, and presumably an enthusiastic



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The story spans a century and deals with social and economic perceptions as well as forest ecology. And it illustrates the difference between turn of the century *logging* and modern *forestry*.

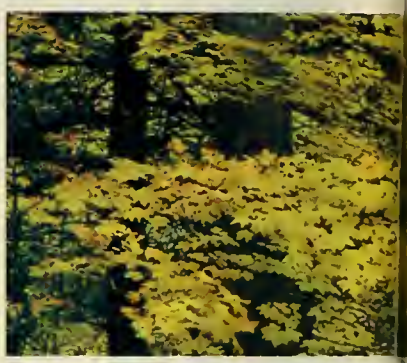
A hundred years ago this was the land of the Big Swedes and rough logging camps. The Great Northwoods. Loggers came to cut what they needed and move on. In terms of the times, this seemed no great evil. After all, "forests were endless." There were no incentives to stay and replant. Supply exceeded demand tenfold.

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But the forests weren't endless. And by the 1920s the best timber in the region was gone.

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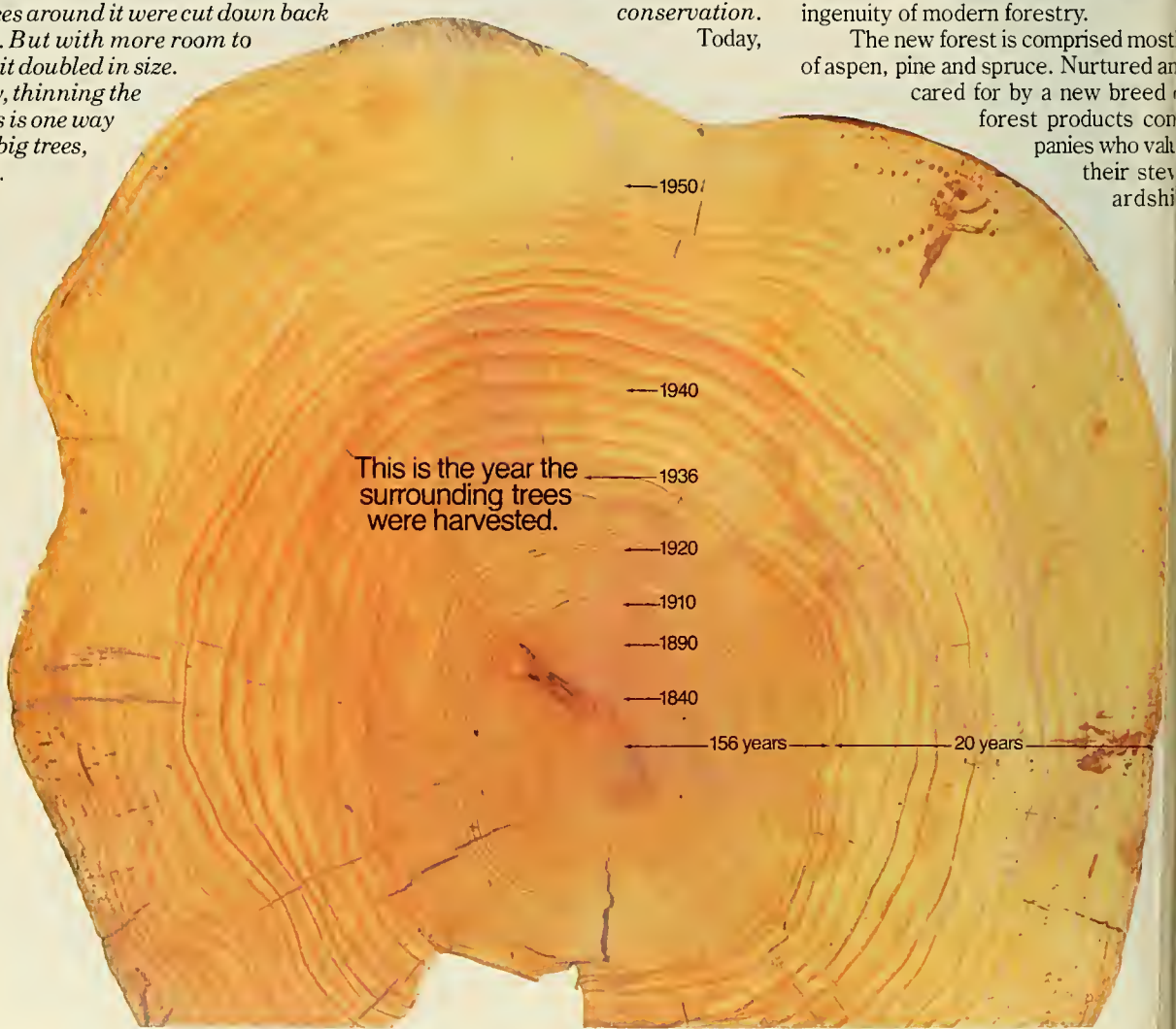
Today, much of the forest is making a comeback thanks to the resilience of nature and the ingenuity of modern forestry.



Today, Paul Bunyan's forests are thriving.

The new forest is comprised mostly of aspen, pine and spruce. Nurtured and cared for by a new breed of forest products companies who value their stewardship.

After 156 years, this Eastern Hemlock was still too small to harvest when the trees around it were cut down back in '36. But with more room to grow, it doubled in size. Today, thinning the forests is one way to get big trees, faster.



TREE IS WORKING



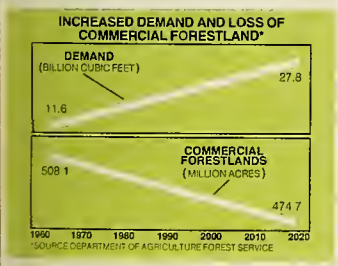
the land. They plant, thin, fertilize and rvest. Little is wasted. Even aspen, ce considered "weed," is now used for per. In fact, nearly every part of every rvested tree is used, right down to the wdust. And where natural regenera- n is slow, foresters handplant the next neration of trees.

The result is a better quality forest. e that is actually more productive than ul Bunyan's.

Operation Double Tree: Why it's needed and how it works.

In the U.S. alone, the demand for wood and paper products is expected to *double* in less than 50 years.

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This is what Operation Double Tree is all about. But it's more than words. Here are some examples of how this practical brand of twentieth century conservation is working in the Lake States.

Managing The New Forest.

Item: In Minnesota, Boise Cascade gets more out of each harvest with a program that turns edgings, sawdust and other sawmill waste into useful wood byproducts. Genetic research has even begun on the trees themselves, finding ways to make them grow faster and stronger. In the future these are the trees that will give us more wood, better wood, in a shorter amount of time.

Item: At the Cloquet Forest Tree Nursery in Minnesota, Potlatch is raising 250,000 seedlings a year in its greenhouse. Grown in small plastic containers, it takes the seedlings just six months to reach the size of two-year-old seedlings grown outdoors.

Now, instead of waiting several years for natural regeneration, foresters can promptly replant harvest sites and give the new forests a healthy head start.



Seeds for regeneration are collected by hand.

Item: In Michigan, Packaging Corporation of America is recycling the sludge from its own water treatment plant to use as a fertilizer on crops of hybrid aspen. The trees are planted in rows, carefully spaced for weed control.

Packaging Corporation foresters expect their methods to produce mature aspen in as little as 15 or 20 years, compared to the 50- to 60-year period normal for wild, untended aspen. The new aspen will not only be ready for harvest sooner, but will have a better quality fiber and higher resistance to disease.

Item: On Blandin Paper Company plantations in Minnesota, foresters and geneticists are working together to improve stands of trees. Using fast-growing white spruce on sites cleared of slower growing species, Blandin expects to double wood yield in the future.

A Long Way To Go.

So there's progress with Operation Double Tree in the Lake States, and in forests all across the country. But we still have a long way to go.

On the average, industry lands grow 50 percent more wood than the lands



We depend on trees for countless everyday products.

owned by government and private individuals. Yet, even here, there's room for improvement.

Overall, the American forest is only half as productive as it could be. And this is a waste. But by working together, all timber growers—private owners, industry and government—can learn to make the most productive use of our remaining commercial forests.*

Industry has invested millions to make the concept a reality. But money isn't enough.

Leaders and landowners alike must understand the problem. And, more important, the solution.

For information, write for our free booklet, "Managing the Great American Forest," American Forest Institute, P.O. Box 873, Springfield, VA 22150.

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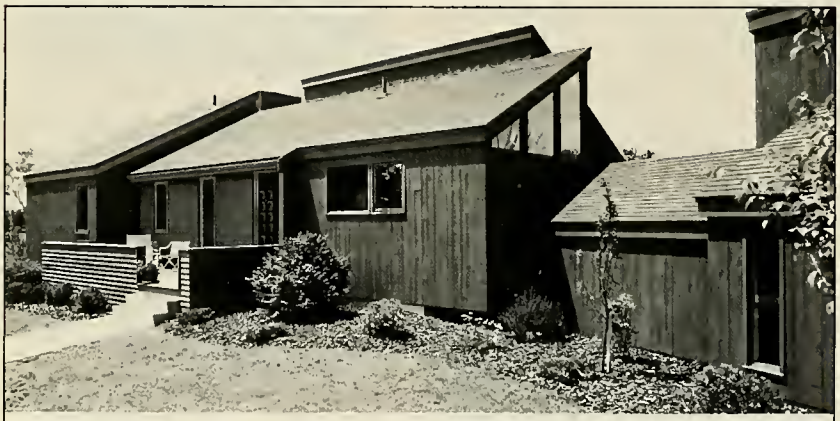
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amateur interest might lead to serious studies, so one is at least introduced to taxonomy. In any event, one starts with the loons and ends with the longspurs and snow buntings in the major field guides because that's the way the American Ornithologists' Union presents them in the official *Check-list*.

But now Knopf and the National Audubon Society have taken a new step in the march to the amateurs' tune. In this two-volume field guide they have evidently decided to aim directly for the inexperienced birder to whom the science matters little and may even be confusing. They have ignored the checklist order to present the birds according to (roughly) shape, color, and habitat. The traditional use of stylized, painted illustrations has also been abandoned, in favor of color photographs showing the birds "as they really are." The sum total is often attractive, but it is not without its faults.

First, the pluses: The texts are good to excellent, and a nice touch has been added. Each entry ends with a chatty note, which contributes to the enjoyment of the birds. Bull and Farrand in particular seem to have taken splendid advantage of extra text space opened by Knopf, which has printed the text on "dictionary paper," a commendable choice that gives each book more pages without adding greatly to bulk or weight. The text pages are also nicely dressed here and there with black-and-white drawings. The photographs are generally good, and some are truly fine, although occasionally the printing blurs and muddies them. The photo sections invite browsing, and many neophyte birders will enjoy flipping these pages to find the bird that has just puzzled them. They will doubtless admire the way the plates have been keyed—thumb-indexed with bird-category shapes, and each category organized internally according to shapes and colors. And the less than expert can make some good use of the way the text is set up, not in the regular order, but by habitats. Going birding tomorrow in a California valley or off the Atlantic shore? Then read up on the birds in the "Grasslands and Savannas" segment of the *Western* guide or the "Open Ocean" section in the *Eastern* guide, to get acclimated and whet your appetite.

However, the minuses are considerable. The photographs simply don't do justice to some species. Many plumage variations, particularly of immature and autumn birds, are left out of the photo sections, guaranteeing the neophyte's bewilderment. And the value of the keys (aside from all the page turning they require) is limited. The very example used in the *Eastern* guide to show how the keys work depends on a color and a habitat difference between the *white*-breasted nuthatch of the "Deciduous Forest" section and the *red*-breasted nuthatch of the "Coniferous Forest," but the photograph given of the white-breasted nuthatch shows a lot of pale cinnamon feathering underneath *and* places the bird in an evergreen setting. Identification is just not cut and dried, but when an editor starts divvying up species into habitats (not to mention distinctive colors) some arbitrary decisions have to be made. So in the *Eastern* guide, for instance, don't look for the great blue heron among the birds of the "Seashore"—or for *any* long-legged wader except the reddish egret. Don't look for the herring or the ring-billed gull there, either, or the common tern. They're all back in the "Salt Marshes" section or the "Freshwater Marshes" or in "Lakes, Ponds, Rivers." Don't expect to find nuances gracefully dealt with by these keys: don't look for the seaside and sharp-tailed sparrows in the same estuarine marsh, although likely they're both there; don't seek the photograph of the black-and-white warbler among the tree-clinging birds, nor that of the least sandpiper among the perching birds.

Once a birder becomes serious about the sport and familiar with the territory, he or she will need to carry a more scientifically ordered and less-confining field guide, and will have to relegate these, with their good texts, to the role of tag-along or shelf reference. Still the Audubon-Knopf books are nice to look at and can be helpful, particularly to the beginning and casual birder.

Michael Harwood, who has written several books on birds and man, wrote the text for Eliot Porter's Moments of Discovery: Adventures with American Birds.

Science Hobbies

by James Mullaney
Astronomy Writer/Consultant

New Telescope Design Makes Astronomy Accessible To Anyone!

Astroscan 2001 – First "Instant"-Use Astronomical Scope

The amazing popularity of motion pictures such as Star Wars and Close Encounters and TV programs like Star Trek, Space 1999 and Logan's Run confirm the fact that Americans are looking skyward as never before. Astronomy is the *NEW HOBBY* of the 70's!

Until now, though, getting into astronomy the right way has not been easy. Reason: the basic tool, the astronomical quality telescope has simply been too costly or too difficult to use.

But, today, there's good news for would-be space watchers. Edmund Scientific, a company long known for coming up with top quality, affordable scientific instruments has created an unusual looking, unusually effective, unusually *inexpensive* telescope you can use to get into this exciting hobby.

It's Astroscan 2001, a telescope so different and so precise even professional astronomers have raved about it. And at just $149.95, it's one of the best telescope buys available.

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Edmund Scientific has devoted more than two years of concentrated engineering and product development to produce this special instrument. The objectives were simple but challenging. The newest Edmund Scientific telescope had to: • give bright, clear views of the stars, the planets, the moon • be lightweight for extreme portability; convenient for hikes, bike trips, vacations • be simple to set up and use so anyone, even a young child, could enjoy the exciting hobby of astronomy • and, most important, be affordable!



The Astroscan 2001 is among the most portable astronomical telescopes available. It sets up in seconds and is so easy to use even children can enjoy it on their own.

The 2001 is a classic Newtonian reflector telescope, using the same basic optical design as the largest observatory instruments. Light from distant celestial objects enters through an optically-coated window, is reflected and focused by a 4¼" highly-polished parabolic mirror, reflected onto a secondary flat-surfaced mirror and through a 28mm magnifying eyepiece, to your eye. The fine optics in Astroscan are better than those found in the world's best cameras.

Astroscan weighs just over 10 pounds and is only 17 inches long. The attractively styled 2001 body is ruggedly constructed of high-impact red styrene. Its uniquely designed aluminum mount and fingertip focusing enables anyone to set up and use this fine instrument in minutes.

The Edmund Scientific Astroscan 2001 is now in full production and available for immediate shipment.

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Celestial Events

Thomas D. Nicholson

Sun and Moon The sun is in the constellation Capricornus until mid-February. It moves into Aquarius on the 16th and into Pisces about March 12. Its motion through this part of the zodiac quickly takes it closer to the equatorial plane. This is evident in the rapid lengthening of daylight that we will experience (nearly three minutes a day in the mid-latitudes). By the end of February, the sun will be above the horizon for eleven hours and twenty minutes a day, an hour and ten minutes longer than at the beginning of the month.

The moon is just past last-quarter on February 1, and will remain a morning object through new moon on the 7th. The evening crescent should be visible by the 10th. The moon will remain an object of the early evening sky through first-quarter on the 14th, full moon on the 22nd, and for several more nights as it wanes into its gibbous phase. Last-quarter moon will occur again on March 2 and new moon on March 8. On the 16th of February and again on the 15th of March, the moon will cover the star Aldebaran (the brightest star in Taurus). The occultation, as this event is called, will be visible in the northern part of North America on February 16, but will not be visible to North American observers during the March event. The moon is at perigee (nearest the earth) on the 5th and at apogee (farthest from the earth) on the 17th of February and March.

Stars and Planets Mars, Jupiter, and Saturn are bright and well placed in the evening sky during February. At dusk, Jupiter will be the brightest of the three, well up in the south, midway between Aldebaran and Castor and Pollux (the "twins" in Gemini). Mars is to the left and lower than Jupiter, close to Castor and Pollux and brighter than either. Saturn will rise in the east, very close to, and a little brighter than, Regulus in Leo. Jupiter sets shortly after midnight, Mars a few hours before sunrise, and Saturn at sunrise. Venus is also an evening star, and you may be able to see it low in the west after sundown by mid-March.

February 15: Early this evening (about 10:00 P.M., EST, and an hour earlier in each time zone to the west), the waxing gibbous moon moves slowly past Aldebaran, covering the star for some observers in North America. This evening, Saturn (near Regulus) is located directly opposite the sun. The planet rises at sunset, sets at sunrise, and then becomes an evening star.

February 16: Mars has been moving nearer to Pollux. Tonight it is closest (conjunction). It then begins to move off to the right (west).

February 17: The bright object nearest the moon tonight is Jupiter. It is the brightest starlike object in the sky.

February 19: The moon passes beneath Mars today, nearest at about 3:00 P.M., EST, moving slowly away from the planet during the evening. Jupiter (to the right of Mars) becomes stationary among the stars. It had been moving slowly toward Aldebaran (to its right), but it now begins to move away to the east.

February 21–22: The moon moves from the right to left of Saturn in the evening sky. Conjunction (when Saturn is nearest) is at 9:00 A.M., EST, on the 22nd.

February 27: Mercury, at superior conjunction, becomes an evening star.

March 2: Mars ends its westerly (retrograde) motion past Pollux. It now begins moving to the left (east) toward the star once more.

March 12: Mercury and Venus are in conjunction in our evening sky, but they set too soon after sundown to be easily seen.



★Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:10 P.M., EST, on February 1; 10:15 P.M., EST, on February 15; 9:25 P.M., EST, on February 28; and 8:25 P.M., EST, on March 15; but it can also be used for an hour before and after those times.



Helmut Wimmer

Additional Reading

Sea Bird Diversity (p. 46)

For a review of the topic of species distribution, see Robert H. MacArthur's *Geographical Ecology: Patterns in the Distribution of Species* (New York: Harper & Row Publishers, 1972), which includes an eight-page bibliography. Also general in its approach is Rachel L. Carson's *The Sea Around Us* (New York: New American Library, 1954, $1.50 in paperback). Carson provides readable information about the physical structure of the seas and their natural history. Well illustrated and charmingly written, *Ocean Wanderers* by Ronald M. Lockley (Harrisburg: Stackpole Books, 1974) is the most recent general book on sea bird behavior and biology.

A technical work directly related to the subject of sea bird species diversity in the Bering Sea is "Did Santa Rosalia Like Sea-birds?" by Miklos Udvardy, in *Proceedings of the 16th International Ornithological Congress*, 1976 (pp. 739–46), edited by H. J. Frith and J. H. Calaby. Udvardy compares the number of species per given area at different latitudes, and his article includes a short bibliography. Two works represent a summary of oceanographic work in the Bering Sea during the early 1970s. *Bering Strait: The Regional Physical Oceanography*, by L. K. Coachman et al (Seattle: University of Washington Press, 1976) presents the most recent structural data for this part of the world. *Oceanography of the Bering Sea* (College, Alaska: Institute of Marine Science, University of Alaska, 1974), edited by Donald W. Hood and E. J. Kelley, contains information on fish and sea mammal productivity and animal distribution for the Bering Sea region.

Buzkashi (p. 54)

"Bold Horsemen of the Steppes," by Sabrina and Roland Michaud (*National Geographic*, November 1973, pp. 634–69), is a colorful treatment of the Turkoman people who originated *buzkashi*. Photographs and descriptive text fill pages 661–69. For general background information on Afghanistan and its people, there is Louis Dupree's *Afghanistan* (Princeton: Princeton University Press, 1973), which includes an excellent bibliography.

One may see the game in action in the super 8, silent color movie, *Buzkashi—The National Game*, which was made in 1975 by Arthur C. Twomey for Grise Inc. This is released by Sound Book Press Society of New York, with a teacher's guide, as number 6 in the series "Afghanistan: The Land and the People."

In 1968, Farrar, Straus published French writer Joseph Kessel's novel about *buzkashi, The Horsemen*, and the following year, John Frankenheimer directed a film based on Kessel's book. Louis Dupree discusses both in "Kessel's '*The Horsemen*': The Culture, the Book, the Movie," in the November 1976 issue of *Fieldstaff Reports*. Copies available at $1.00 each from American Universities Field Staff, P. O. Box 150, Hanover, New Hampshire 03755.

Crystal Symmetry (p. 64)

Scientists in the Soviet Union are leaders in the field of crystal morphology, and the reader might therefore wish to consult the English translation, *Lectures on Crystal Morphology*, by I. I. Shafranovskii, published in 1973 by the National Bureau of Standards, U.S. Department of Commerce, Washington, D.C. These lectures were given by Shafranovskii at various Russian universities in the recent past and contribute a good review of the subject. Two other sources can be consulted for background mineralogical information: John Sinkankas's *Mineralogy for Amateurs* (New York: Van Nostrand Reinhold Co., 1964) and Cornelius S. Hurlbut, Jr., and Cornelius Klein's *Manual of Mineralogy*, the nineteenth edition of which was published in 1977 by John Wiley & Sons of New York. This latter work is the most recent in the long line begun by James Dwight Dana in the nineteenth century, and is often used as a reference manual in conjunction with beginning college course work in mineralogy. The Sinkankas book is well illustrated and very readable, and is slanted toward the identification of specimens by collectors. An enjoyably written addition to the subject of symmetry in general is A. V. Shubnikov's *Symmetry in Science and Art*, translated from the Russian by David Harker (New York: Plenum Press, 1974).

Dust Bowl (p. 72)

Vance Johnson took a comprehensive look at the dust storms of the 1930s in *Heaven's Tableland: The Dust Bowl Story*, which is part of the series "FDR and the Era of the New Deal" (New York: Da Capo Press, Inc., 1974). A series of articles by James C. Malin is interesting in that it assumes the point of view that dust storms have been a fact of life throughout recorded history on the plains of America. Under the title "Dust Storms" these appeared in the May, August, and November 1940 issues of *Kansas Historical Quarterly* (pp. 129–44, 265–96 and

391–413, respectively). Long quotations from editorials and articles in newspapers of the 1890s make this fascinating reading.

Photographer Margaret Bourke-White, coauthor with Erskine Caldwell of the depression-era *You Have Seen Their Faces* (New York: Arno Press, Inc., 1975, $15.00), was also responsible for a short, evocative memoir of her photographic work in the dust bowl. The reader may wish to consult "Dust Changes America," (*The Nation,* May 22, 1935, pp. 597–98). Caroline A. Henderson, wife of a farmer and participant-observer of the dust storms, wrote "Letters from the Dust Bowl" (*Atlantic Monthly*, May 1936, pp. 540–51) and "Spring in the Dust Bowl" (*Atlantic Monthly*, June 1937, pp. 715–17).

Reef Fishes (p. 84)

Most of the literature on adaptive coloration and patterning in animals relates to camouflage rather than to attraction. G. W. Barlow's article, "The Attitude of Fish Eye-Lines in Relation to Body Shape and to Stripes and Bars," in *Copeia* (1972, pp. 4–12) takes this classical approach. *Adaptive Coloration,* by Hugh B. Cott (London: Methuen & Co., 1940), although old, remains the best general survey of the subject available. Eye signals, hiding, and ornamentation are all dealt with. Unfortunately, the work's illustrations, with the exception of the frontispiece, are all in black and white. Wolfgang Wickler's *Mimicry in Plants and Animals* (New York: McGraw-Hill Book Co., 1968) discusses the color patterns of animals and contains bibliographic citations. This book is available in paperback for under $3.

Pamela Haas



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Announcements



We've Been Here 100 Years, a photography exhibit commemorating the opening of the Museum at its present location, will be on view through February 1978 in the Hall of Northwest Coast Indians on the first floor.

"Creature Tales: A Theatre Presentation Based Upon the Legends and Poetry of Amphibians and Reptiles" is a history, mythology, and interpretation of the origins of reptiles and amphibians, created by **Richard Lewis and The Touchstone Players.** Through dance, mime, music, and narration, "Creature Tales" will be presented on two Saturdays, February 11 and 18, at 11:00 A.M. in the Museum's Education Hall, located on the first floor.

Richard Lewis and his associate Joyce Timpanelli will also present **Poems and Tales of Amphibians and Reptiles** on Sunday, February 12, at 2:00 P.M. in the Hall of Mexico and Central America. And on February 15 and 22, at 7:00 P.M., Joyce Timpanelli will present some original and traditional tales in the Hall of Northwest Coast Indians. The first program will be "Tales of Animal/Humans"; the second, "Tales of Death and Rebirth."

All of these programs are for children and adults. They will each last for less than an hour, and are free to those who have paid the Museum's entrance fee.

In 1858, David Livingstone, on his third expedition to Africa, traveled up the Zambezi River determined to bring Christianity, commerce, and civilization to the remotest villages. He was the first white man to penetrate the area. On March 1, 1978, African explorer and naturalist Quentin Keynes will narrate **The Zambezi, I Presume,** a film that took him several years to make. Using the landmarks that Livingstone mentioned in his writings, Keynes retraced Livingstone's route. He discovered a village where a 106-year-old man remembered seeing the first white man (who fits Livingstone's description exactly) and was led to an ancient baobab tree carved with Livingstone's initials. The film, an hour's worth of Africa, wildlife and history-come-to-life, will be shown at 8:00 P.M. in the Museum's auditorium. Tickets for associate members and the public are $2.00 and will be available at the auditorium door half an hour before the program begins. Participating and donor members admitted free.

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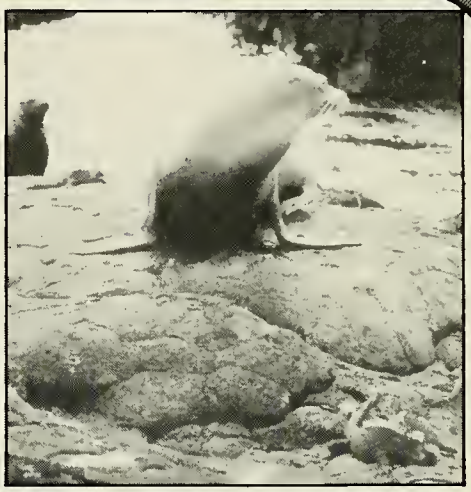
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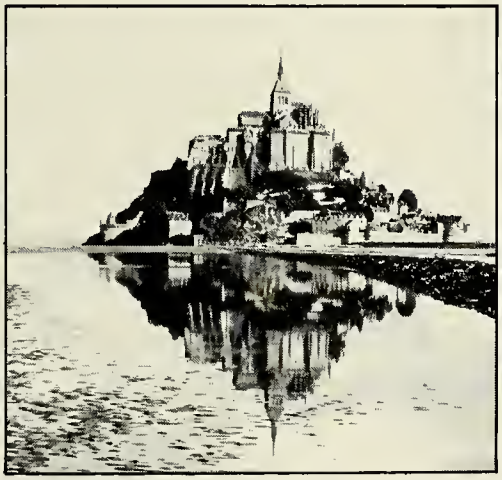
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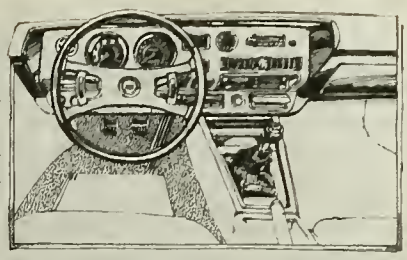
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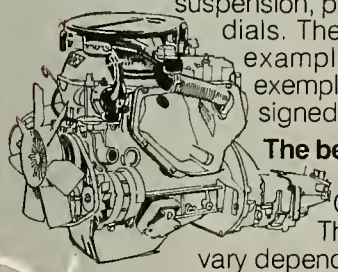
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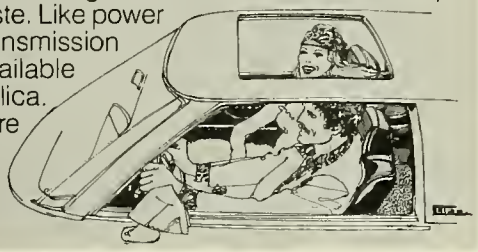
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NATURAL HISTORY

Incorporating Nature Magazine
Vol. LXXXVII. No. 3
March 1978

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Authors

In 1971, while searching for caves in connection with his research on the paleoecology of early humans in North America, **Michael G. Petit** learned of the Eagle Creek bat cave in Arizona. Hooked on the bats, he observed the colony in the cave over a period of six years and documented its precipitous decline. An assistant professor at Colorado State University, Petit has worked as a house mover, pool hustler, and venereal disease control officer for the U.S. Navy. He tap dances and acts in university theatrical productions during the academic year.





David Herlihy teaches history at Harvard University, where he lives with his wife, Patricia, five sons, and one daughter. As comasters of Mather House, the Herlihys "preside over a community of more than four hundred bright and active young men and women." Today's students, Herlihy has found, are interested in social history in general and women's history in particular. He has been concentrating on the history of the family in the Middle Ages and the Renaissance, and plans to investigate the life cycles of Florence's citizens in the fourteenth and fifteenth centuries.

As a Peace Corps volunteer in 1966, **Kenneth W. Smith** arrived in Santiago Sacatepéquez, Guatemala, on the eve of All Saints' Day. The first thing he saw on waking up the next morning were the huge kites flying over the nearby cemetery. Several years after completing his tour of duty, Smith returned to Santiago, this time on a Fulbright-Hays scholarship. His purpose was to study the village's church records as a means of chronicling the political and economic changes in the community since the Spanish conquest. Smith is now using this research in his dissertation for a doctorate in anthropology, which he expects to receive from the University of Minnesota.





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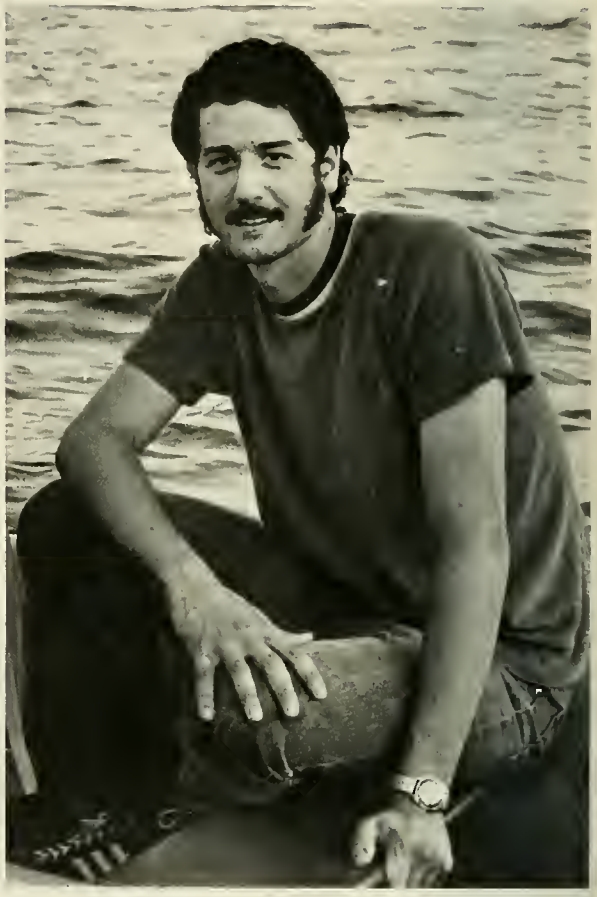
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Born and educated in the Netherlands, biophysicist **Adrianus J. Kalmijn** has been observing the behavior of sharks since his postgraduate days at the University of Utrecht in the 1960s. While teaching and doing research at his alma mater, Kalmijn was invited to work at the Scripps Institution of Oceanography in La Jolla, California. He moved to the United States in 1970 with his family and has lived here ever since. Kalmijn is now an associate scientist in biophysics at the Woods Hole Oceanographic Institution. He has written articles on electroreceptivity in fish for many professional journals and is often a guest lecturer at colleges and universities.

Coauthor **Kenneth Jon Rose** has worked for the past two summers as Kalmijn's research assistant both in the laboratory at Woods Hole and in the field. He has a B.A. in psychology from the University of Connecticut.







Fred B. Eiseman, Jr., is a retired teacher of physics, chemistry, and earth science. Twenty-six years ago, while camping in Utah, he met a girl who had run the Colorado River through Glen Canyon. She convinced him that such a form of boating was high adventure and they've been river running ever since, as husband and wife. He writes, "I find it useful to not belong to conservation-oriented organizations and to be self-employed as a writer and photographer. That way, I can write as I see fit, without having a grant taken away, promotion passed over, or employment terminated." Between trips down the Colorado and through the Grand Canyon, he and his wife are doing a study of the music of Bali.

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Thoreau's Unfinished Business

by Loren Eiseley

Self-knowledge was to be sought beyond the bounds of Walden Pond

The life of Henry David Thoreau has been thoroughly explored for almost a century by critics and biographers, yet the mystery of this untraveled man who read travel literature has nowhere been better expressed than by his old walking companion Ellery Channing, who once wrote: "I have never been able to understand what he meant by his life. Why was he so disappointed with everybody else? Why was he so interested in the river and the woods . . . ? Something peculiar here I judge."

If Channing, his personal friend, was mystified, it is only to be expected that as Thoreau's literary stature has grown, the ever present enigma of his life and thought has grown with it. Wright Morris, the distinguished novelist and critic, has asked, almost savagely, the same questions in another form.

In a less personal context he quotes from Thoreau, who spent two years upon the Walden experiment and then abandoned it, "If we are alive let us go about our business." "But," counters Morris brutally, "what business?" Thoreau fails to inform us. In the words of Morris, Walden was the opening chapter of a life, one that enthralls us, but with the remaining chapters missing.

For more than a decade after *Walden* was composed, Thoreau continued his intensive exploration of Concord, its inhabitants and its fields, but upon the "business" for which he left Walden he is oddly cryptic. Once, it is true, he muses in his journal that "the utmost possible novelty would be the difference between me and myself a year ago." He must then have been about some business, even though the perceptive critic Morris felt he had already performed it and was at loose ends and groping. The truth is that the critic, in a timeless sense, can be right and in another way wrong, for looking is in itself the business of art.

Thoreau was indeed a spiritual wanderer through the deserts of the modern world. Almost by instinct he rejected that beginning wave of industrialism that was later to so entrance his century. He also rejected the peace he had found on the shores of Walden Pond, the alternate glazing and reflection of that great natural eye which impartially received the seasons. It was, in the end, too great for his endurance, too timeless. He was a restless pacer of fields, a reader who, in spite of occasional invective directed against those who presumed to neglect their homes for far places, nevertheless was apt with allusions drawn from travel literature and quick to discern in man uncharted spaces.

"Few adults," once remarked Emerson, Thoreau's one-time mentor and friend, "can see nature." Thoreau was one of those who could. Moreover he saw nature as another civilization, a thing of vaster laws and vagaries than that encompassed by the human mind. When he visited the Maine woods he felt its wind upon him like the closing of a dank door from some forgotten cellar of the past.

Was it some curious midnight impulse to investigate such matters that led Thoreau to abandon the sunny hut at Walden for "other business"? Even at Walden he had heard, at midnight, the insistent fox, the "rudimental man," barking beyond his lighted window in the forest. The universe was in motion, nothing was fixed. Nature was "a prairie for outlaws," violent, unpredictable. Alone in the environs of Walden, Thoreau wandered in the midst of that greater civilization he had discovered as surely as some monstrous edifice come suddenly upon in the Maya jungles. He never exclaimed about the Indian trails seen just at dusk in a winter snowfall—neither where they went nor upon what prairie they vanished or in what direction. He never ventured to tell us, but he was one of those great artist-scientists who could pursue the future through its past. This is why he lives today in the hearts of young and old alike, "a man of surfaces," but such surfaces—the arrowhead, the acorn, the oak leaf, the indestructible thought print headed toward eternity.

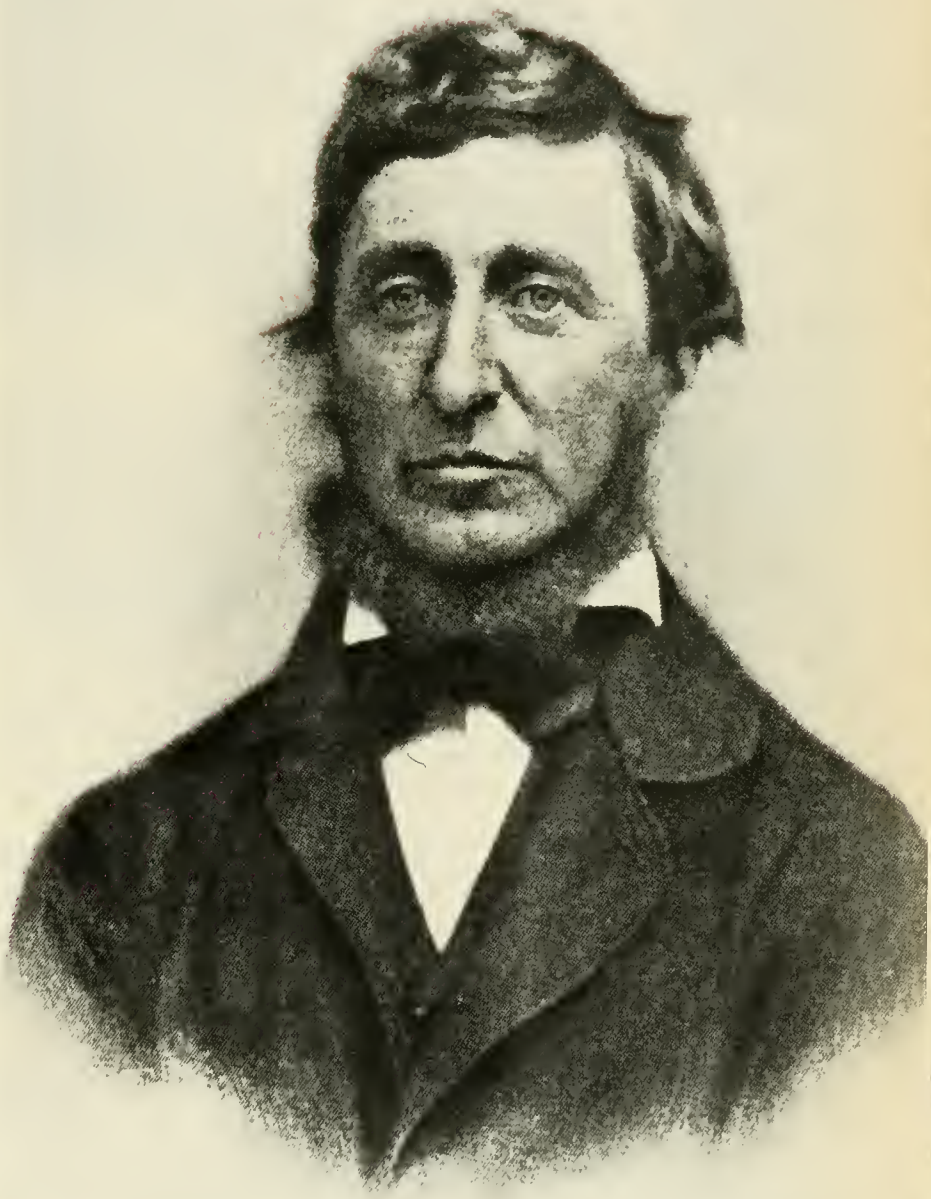
Thoreau, in his final journals, had said that the ancients with their gorgons and sphinxes could imagine more than existed. Modern men, by contrast, could not imagine so much as exists. For more than one hundred years that statement has stood to taunt us. Every succeeding year has proved Thoreau right. The one great hieroglyph, nature, is as unreadable as it ever was and so is her equally wild and unpredictable offspring, man. Like Thoreau, the examiner of lost and fragile surfaces of flint, we are only by indirection students of man. We are, in actuality, students of tha greater order known as nature. It i into nature that man vanishes "Wildness is a civilization othe than our own," Thoreau had ven tured. Out of it man's trail ha wandered. He had come with th great ice, drifting before its vio lence, scavenging the flints it ha dropped. Whatever he was now, th ice had made him, the breath fro the dank door, great cold, and im placable winters.

Excerpted from the book *The Star Thrower*, by Loren Eiseley. To be published by Times Books in June 1978. Copyright © 1978 by the estate of Loren Eiseley.

Thoreau in the final pages of *Walden* creates a myth about a despised worm that surmounts death and bursts from its hidden chamber in a wooden table. Was the writer dreaming of man, man freed at last from the manacles of the ice? Is not the real business of the artist to seek for man's salvation, and by understanding his ingredients to make him less of an outlaw to himself, civilize him, in fact, back into that titanic otherness, that star's substance from which he had arisen? Perhaps encamped sufficiently in the great living web we might emerge again, not into the blind snow-covered eye of Walden's winter, but into the eternal spring man dreams of everywhere and nowhere finds.

Man, himself, is Walden's eye of ice and eye of summer. What now makes man an outlaw, with the fox urgent at his heels, is that one of his eyes is gray and wintry and blind, while with the other is glimpsed another world just tantalizingly visible and dismissed as an illusion. What we know with certainty is that a creature with such disparate vision cannot long survive. It was that knowledge that led Thoreau to strain his eyesight till it ached and to record all he saw. A flower might open a man's mind, a box tortoise endow him with mercy, a mist enable him to see his own shifting and uncertain configuration. But the alchemist's touchstone in Thoreau was to give him sight, not power. Only man's own mind, the artist's mind, can change the winter in man.

On July 14 of the year 1973, I awoke at dawn and saw above my head the chisel marks on an eighteenth-century beam in the Concord Inn. As I strolled up the street toward the cemetery I saw a few drifters, black and white, stirring from their illegal night's sleep



From *Thoreau*, by Henry Seidel Canby © 1939 by Houghton Mifflin Company

among the gravestones. Later I came to the Thoreau family plot and saw the little yellow stone marked "Henry," which no one is any longer sure indicates the precise place where he lies. Perhaps there is justice in this obscurity because the critics are also unsure of the contradictions and intentions of his journal, even of the classic *Walden*. A ghost then, of shifting features, peers out from between the gravestones, unreal, perhaps uninterpreted still.

I turned away from the early morning damp for a glimpse of the famous pond which in the country of my youth would have been called a lake. It was still an unearthly reflection of the sky, even if here and there beer bottles were bobbing in the shallows. I walked along the tracks of the old railroad where Thoreau used to listen to the telegraph wires. He had an eye for the sharp-edged artifact, I thought. He would have transmitted the bobbing bottles, the keys to beer cans, into cosmic symbols, just as he had sensed all past time in the odors of a swamp. "All the ages are represented still," he had said, with nostrils flaring above the vegetation-choked water, "and you can smell them out."

As for arrowheads, he says in a memorable passage, "You would say it had rained arrowheads for they lie all over the surface of America. They are sown like grain . . . over the earth. Each one yields me a thought. . . . It is humanity inscribed on the face of the earth. It is a footprint—rather a mindprint—left everywhere. . . . They are not fossil bones, but, as it were, fossil thoughts forever reminding me of the mind that shaped them. I am on the trail of mind."

Some time ago in a graduate seminar in honor of a visiting eminent prehistorian I watched the scholar and his listeners grapple with the significance of an anciently shaped stone. Not one of those present, involved as they were with semantic involutions, could render up so simple an expression as "mindprint." The lonely follower of the plow at Concord had provided both art and anthropology with an expression of horizon-reaching application that they have inexplicably chosen to ignore.

Mindprints are what the first men left, mindprints will be what the last man leaves, even if it is only a beer can dropped rolling from the last living hand or a sagging picture in a ruined house.

Thoreau had extended his thought prints to something beyond what we of this age would call the natural. He would read them into nature itself, see, in other words, some kind of trail through that prairie for outlaws that had always intimidated him. On mountaintops, he had realized a star's substance, sensed a nature "not bound to be kind to man." Nevertheless he confided firmly to his diary, "the earth which I have *seen* cannot bury me." He searches desperately, all senses alert, for a way to read these greater hieroglyphs in which the tiny interpretable minds of our forerunners are embedded. We, with a sharper knowledge of human limitations and a devotion to the empirical fact, may deny to ourselves the reality of this other civilization within whose laws and probabilities we exist. Thoreau reposed faith in the consistency of nature's habits, but only up to a point, for he was a student of change.

Now Thoreau was a stay-at-home who traveled much in his mind, both in travel literature and beside Walden Pond. I, by circumstance, directly after delivering a lecture at Concord and gazing in my turn at Walden, was forced immediately to turn and fly west to the badlands and dinosaur-haunted gulches of Montana, some of its natives wild, half-civilized still. As I followed our mixed-breed Cheyenne, as ambivalent toward us as the savage blood in his veins demanded, it came to me, as it must have come to many others, that seeing is not the same thing as understanding.

One man sees with indifference a leaf fall; another with the vision of Thoreau invokes the whole of that nostalgic world that we call autumn. One man sees a red fox running through a shaft of sunlight and lifts a rifle; another lays a restraining hand upon his companion's arm and says, "Please. There goes the last wild gaiety in the world. Let it live, let it run." This is the role of the alchemist, the true, if sometimes inarticulate, artist. He transmutes the cricket's song in an autumn night to an aching void in the heart; snowflakes become the flying years. And when, as archeologist, he lifts from the encrusting earth those forgotten objects Thoreau called "fossil thoughts," he is giving depth and tragedy and catharsis to the one great drama that concerns us most, the supreme mystery, man. Only man is capable of comprehending all he was and all that he has failed to be.

On those sun-beaten uplands over which we wandered, every chip of quartzite, every patinized flint gleamed in our eyes as large as the monuments of other lands. Our vision in that thin air was incredibly enhanced and prolonged. Thoreau had conceived of nature as a single reflecting eye, the Walden eye of which he strove to be a solitary part, to apprehend with all his being. It was chance that had brought me in the span of a day to the dinosaur beds of Montana. Thoreau would have liked that. He had always regarded such places as endowed with the vapors of Nox, places where rules were annulled. He had called arrowheads mindprints. What then would he have termed a tooth of *Tyrannosaurus rex* held in my palm? The sign of another civilization, another order of mind? Or that tiny Cretaceous mammal that was a step on the way to ourselves? Surely it represented mind in embryo, our mind, but not of our devising. What would he have called it—that miracle of a bygone moment, the annulment of what had been, to be replaced by an eye, the artist's eye, that nature had never heretofore produced among her creatures? Would he have simply called it "nature," as we sometimes do, scarcely knowing how to interpret the looming inchoate power out of which we have been born? Or would he have labeled nature itself a mindprint beyond our power to read or to interpret?

A man might sketch *Triceratops*, but the alphabet from which it was assembled had long since disappeared. As for man, how had his own alphabet been constructed? The nature in which he momentarily resided was a journal in which the script was always changing, like the dancing footprints of the fox on icy Walden Pond. Here, exposed about me, was the great journal Thoreau had striven to read, the business, in the end, that had taken him beyond Walden. He would

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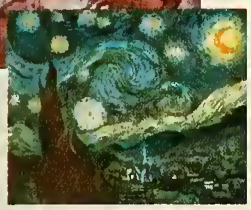
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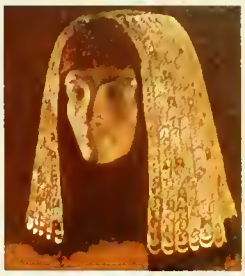
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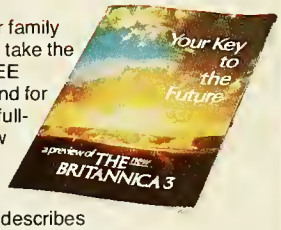
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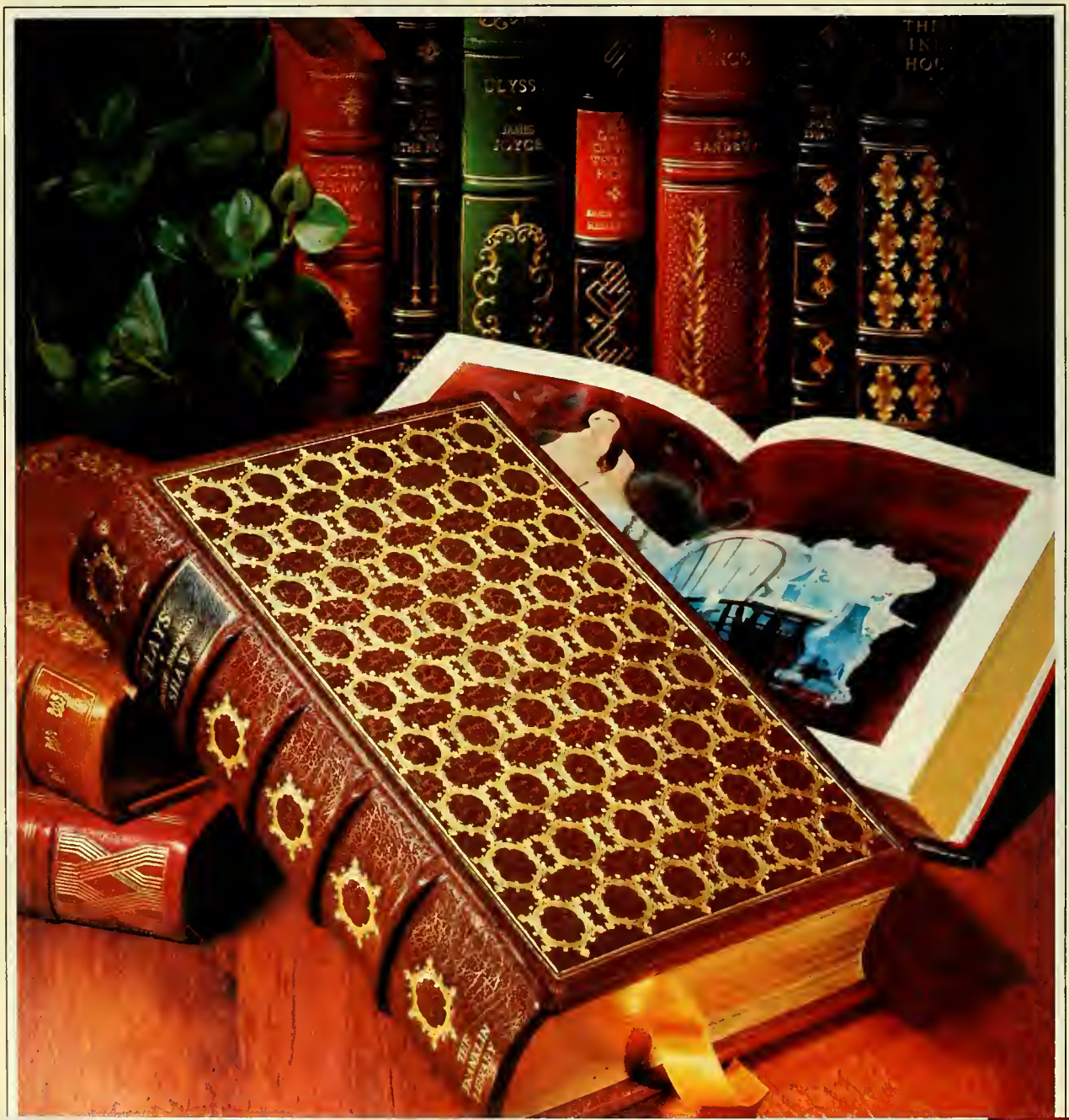
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have been too wise, too close to earth, too intimidated, to have called such a journal human. It was palpably inscribed from a star's substance. Tiny and brief in that journal were the hieroglyphs of man. Like Thoreau, we had come to the world's end, but not to the end of nature, not to the end of time. All that could be read was that we had a past; that was something no other life on the planet had learned. There was, we had also ascertained, a future.

In the meantime, Thoreau would have protested, there is the eye, the sun and the eye. "Nothing must be postponed; find eternity in each moment." But how few of us are endowed to sustain Thoreau's almost diabolical vision. Here and here alone the true alchemist must come to exist in each of us. It is ours to transmute, not iron, not copper, not gold, but our tracks through nature, see them finally attended by self-knowledge, by the vision of the universal eye—that faculty possessed by the alchemist at Walden Pond.

But why, why had he left the sunny doorway of his hut in Walden for unknown mysterious business? Had he not written as though he had settled down forever? Why had Channing chronicled Thoreau's grievous disappointments? What had he been seeking and how had it affected him? If Walden was the opening chapter of a life, might not there still be a lurking message, a termination, a final chapter beyond his recorded death?

It was evident that he had seen the whole of American culture as copper tinted by its antecedents, its people shadowy and gigantic as figures looming indistinctly in some Indian-summer haze. He had written of an old tree near Concord penetrated by a flying arrow with the shaft still attached. Some of the driving force of that flint projectile still persisted in his mind. Perhaps indeed those points that had once sung their message through every glade of the eastern woodland had spoken louder than the telegraph harp to which his ears had been attuned at Walden. Protest as he would, cultivate sauntering as he would, abhor as he would the rootless travelers whose works he read by lamplight, he was himself the eternal traveler. On the mountains of New Hampshire he had found "small and almost uninhabited ponds, apparently without fish, sources of rivers, still and cold, strange as condensed clouds." He had wandered without realizing it back into the time of the first continental ice recession.

"It is not worth the while to go around the world to count the cats in Zanzibar," he once castigated some luckless explorer, but why then this peering into lifeless tarns or engrossing himself with the meteoritic detritus of the Appalachians? Did he secretly wish to come to a place of no more life, where a man might stiffen into immobility as I had found myself freezing into the agate limbs of petrified trees in Montana? He admitted that he would gladly fall "into some crevice along with leaves and acorns." "There is no more fatal blunderer," he protested, "than he who consumes the greater part of life getting a living." He had emphasized that contemplative view at Walden, lived it, in fact, to the point where the world came finally to accept him as a kind of rural Robinson Crusoe whom, as the cities grew, it might prove wise to emulate.

"I sat in my sunny doorway," he ruminated, "from sunrise till noon, rapt in revery, amidst the pines and hickories and sumachs, in undisturbed solitude and stillness, while the birds sang around or flitted noiseless through the house, until by the sun falling in at my west window, or the noise of some traveler's wagon on the distant highway, I was reminded of the lapse of time. I grew in those seasons like corn in the night."

This passage would seem to stand for the serene and timeless life of an Oriental sage, a well-adjusted man, as the psychiatrists of our day would have it. Nevertheless this benign façade is deceptive. There is no doubt that Thoreau honestly meant what he said at the time he said it, but the man was storm-driven. He would not be content with the first chapter of his life; he would, like a true artist, dredge up dreams even from the bottom of a pond.

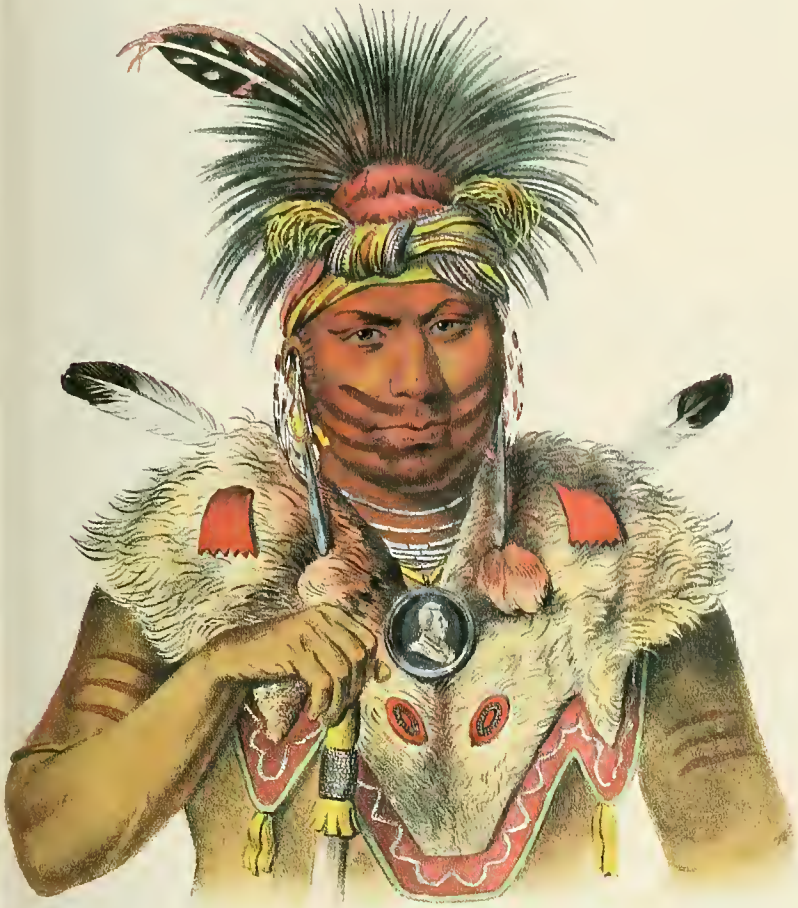
In the year 1837 Thoreau confided abruptly to his journal: "Truth strikes us from behind, and in the dark." Thoreau's life was to be comparatively short and ill-starred. Our final question must, therefore, revolve, not about wanderings in autumn fields, not the drowsing in pleasant doorways where time stood still forever, but rather upon the leap of that lost arrow left quivering in an ancient oak. It was, in symbol, the hurtling purposeful arrow of a seemingly aimless life. It has been overlooked by Thoreau's biographers, largely because they have been men of the study or men of the forest. They have not been men of the seashore or men gifted with the artist's eye. They have not trudged the naturalist's long miles through sea sand, where the war between two elements leaves even the smallest object magnified, as the bleached bone or broken utensil can be similarly magnified only on the dead lake beaches of the west.

Thoreau had been drawn to Cape Cod in 1849, a visit he had twice repeated. It was not the tourist resort it is today. It was still the country of men on impoverished farms, who went to sea or combed the beaches like wreckers seeking cargo. On those beaches, commented Thoreau, in a work that he was destined never to see in print, "a house was rarely visible . . . and the solitude was that of the ocean and the desert combined." Here, recorded the chronicler, was a wilder, less human nature. Objects on the beach, he noted, were always more grotesque and dilated than upon approach they proved to be. A cast-up pair of gloves suggested the reality of hands.

Thoreau's account, in *Cape Cod*, of the "charity house" to which his wanderings led him takes on a special meaning. I think it embodies something of a final answer to Channing's question about Thoreau's disappointment in his fellow men. Published two years after his death, it contains his formulation of the end of his business, or perhaps I should say, of his quest. Hidden in what has been dismissed as a mere book of travel is an episode as potentially fabulous as that of Melville's great white whale.

First, however, I must tell the story of another coast because it will serve to illuminate Thoreau's final perception. A man, a shore dweller on Long Island, told me of his discovery in a winter dawn. All night there had been a heavy surf and freezing wind. When he came to stroll along his beach at morning

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he had immediately seen a lifeboat cast upon the shingle and a still, black figure with the eastern sun behind it on the horizon. Gripped by a premonition he ran forward. The seaman in oilskins was alone and stiffly upright. A compass was clutched in his numb fingers. The man was sheeted in ice. Ice over his beard, his clothing, his hands, ice over his fixed, open eyes. Had he made the shore alive but too frozen to move? No one would ever know, just as no one would ever know his name or the sinking vessel from which he came. With desperate courage he had steered a true course through a wild night of breakers only to freeze within sight of help.

In those fishing days on Cape Cod, Thoreau came to know many such stories—vessels without weather warnings smashed in the winter seas, while, perhaps, a pittance of soaked men gained the shore. The sea, the intolerable sea, tumbled with total indifference the bodies of the dead or the living who were tossed up through the grinding surf of winter. These were common events in the days of sail.

The people who gained a scant living along that coast entertained, early in the nineteenth century, the thought that a few well-stocked sheds, or charity houses, might enable lost seamen who made the shore to warm and feed themselves among the dunes till rescued. The idea was to provide straw and matches and provender, supervised and checked at intervals by some responsible person. Impressed at first by this signal beneficence of landsmen, Thoreau noted the instructions set down for the benefit of mariners. Finally, he approached one such charity house. It appeared, he commented, "but a stage to the grave." The chimney had fallen. As he and his companion wished to gain an idea of a "humane house," they put their eyes, by turns, to a knothole in the door. "We had," Thoreau comments ironically, "some practice at looking inward—the pupil becomes enlarged. Nature is never so dark that a patient eye may not prevail over it."

So there, at last, he saw the end of his journey, of the business begun at Walden. He was peering into the charity house of man, upon a Cape Cod beach. For frozen, shipwrecked mariners he saw a fireplace with no matches, no provisions, no straw upon the floor. "We looked," he said, "into the bowels of mercy, and for bread we found a stone." Shivering like castaways, "we looked through the knothole into that night without a star, until we concluded it was not a humane house at all." The arrow Thoreau had followed away from Walden had pierced as deep as Captain Ahab's lance. No wonder the demoniacal foxes leaping at Thoreau's window had urged him to begone. He had always looked for a crevice into the future. He had peered inward instead. It was ourselves who were rudimental men.

A hundred years after Thoreau's death people were still trying to understand what he was about. They were still trying to get both eyes open. They were still trying to understand that he had brought something to share with his fellows, something that, if they partook of it, might transpose them to another world.

I had thought, staring across an angular gravestone at Concord, and again as I held a wind-varnished flint in Montana, that "sharing" could be the word. It was appropriate, even though Thoreau in a final bitterness had felt sharing to be as impoverished as the charity house for sailors—a knothole glimpse into the human condition. How then should the artist see? By an eye applied to a knothole? By a magnification of sand-filled gloves washed up on a beach? Could this be the solitary business that led Thoreau on his deathbed to mutter, whether in irony or confusion, "One world at a time"?

This is the terror of our age. How should we see? In what world are we? For we have fallen out of nature and see sometimes more and sometimes less. We see the past, the looming future, and then, so fearfully is the eye confused, that it stares inverted into a charity house that appears to reflect a less than human heart. Is this Thoreau's final surrealist vision, his glance through the knothole into the humane house? It would appear at least to be a glimpse from one of those two great alternating eyes at Walden Pond from which in the end he had fled—the blind eye of winter and that innocent blue pupil beside which he had once drowsed when time seemed endless. Both are equally real, as the great poets and prophets have always known, but it was Thoreau's tragic destiny to see, with eyes strained beyond endurance, man subsiding into two wrinkled gloves grasping at the edge of infinity. It is his final contribution to literature, the final hidden conclusion of an unwritten life whose first chapter Morris had rightly diagnosed as Walden.

There is an old biblical saying that our days are prolonged and every vision fails us. This I would dispute. The vision of the great artist does not fail. It sharpens and refines with age until everything extraneous is pared away. "Simplify," Thoreau had advocated. Two gloves, devoid of flesh, clutching the stones of the ebbing tide become, transmuted, the most dreadful object in the world.

"There has been nothing but the sun and eye from the beginning." Thoreau had written when his only business was looking and he grew, as he expressed it, "like corn in the night." The sun and the eye are the two aspects of nature that are irremediably linked. But the eye of man constitutes an awesome crystal whose diffractions are far greater than those of any Newtonian prism.

We see, as artists, as scientists, each in his own way, through the inexorable lens we cannot alter. In a nature that Thoreau recognized as unfixed and lawless anything might happen. The artist's endeavor is to make it happen—the unlawful, the oncoming world, whether endurable or mad, but shaped always by the harsh angles of truth—the truth as glimpsed through the terrible crystal of genius. This is the one sure rule of that other civilization, which we have come to know is greater than our own. Thoreau called it, from the first, "unfinished business," when he turned and walked away from his hut at Walden Pond.

The late Loren Eiseley—naturalist, humanist, and poet—was Benjamin Franklin Professor of Anthropology and the History of Science at the University of Pennsylvania. All the Strange Hours, *Eiseley's autobiography, was his last major prose work. He died in July 1977.*

by Stephen Jay Gould

Crazy Old Randolph Kirkpatrick

When he was wrong,
he was very, very wrong,
but when he was right,
he was right on

Oblivion, not infamy, is the usual fate of a crackpot. I shall be more than mildly surprised if any reader (who is not a professional taxonomist with a special attachment to sponges) can identify Randolph Kirkpatrick. On the surface, Kirkpatrick fit the stereotype of a self-effacing, mild-mannered, dedicated, but slightly eccentric British natural historian.

Kirkpatrick was the assistant keeper of "lower" invertebrates at the British Museum from 1886 until his retirement in 1927. (I have always admired the English penchant for simple, literal terms such as lifts and flats for our elevators and apartments. We use the Latin *curator* for guardians of museum collections; the British call them "keepers." We, however, have done better in retaining "fall" for their "autumn.") Kirkpatrick trained as a medical student, but decided on a "less strenuous career" in natural history after several bouts with illness. He chose well, for he traveled all over the world searching for specimens and lived to be eighty-seven. In the last months of his life, in 1950, he continued to pedal his bicycle through London's streets.

Early in his career, Kirkpatrick published some sound taxonomic work on sponges, but his name rarely appears in scientific journals after the First World War. In an obituary note, his successor attributed this halt in mid-career to Kirkpatrick's behavior as "an ideal public servant." "Unassuming to a fault, courteous and generous, he would spare no effort to help either a colleague or a visiting student. It was in all probability his extreme willingness to interrupt whatever he was doing to help others that prevented his completing his work."

Kirkpatrick's story, however, is not quite so simple and conventionally spotless. He did not stop publishing in 1915; instead, he shifted to private printing for a series of works that he knew no scientific journal would touch. Kirkpatrick spent the rest of his career developing what has to be the nuttiest of crackpot theories developed in this century by a professional natural historian (and keeper at the staid British Museum, no less). I do not challenge this usual assessment of his "nummulosphere" theory, but I will stoutly defend Kirkpatrick.

In 1912, Kirkpatrick was collecting sponges off the island of Porto Santo in the Madeira group west of Morocco. One day, a friend brought him some volcanic rocks collected on a peak 1,000 feet above sea level. Kirkpatrick describes his great discovery: "I examined them carefully under my binocular microscope and found to my amazement traces of nummulitic disks in all of them. Next day I visited the place whence the fragments had come."

Now *Nummulites* is one of the largest forams that ever lived (forams, single-celled creatures related to amoebas, secrete shells and are thereby commonly preserved as fossils). *Nummulites* looks like the object that provided its name: a coin. Its shell is a flat disk an inch or two in diameter. This disk is built of individual chambers, one following the next and all wound tightly into a single coil. In fact, the shell looks much like a coil of rope, appropriately scaled down. *Nummulites* was so abundant in early Tertiary times (about 50 million years ago) that some rocks are composed almost entirely of its shells; these are called "nummulitic limestones." The fossils are so common around Cairo that the Greek geographer Strabo identified them as petrified lentils left over from rations doled out to slaves who had built the Great Pyramids.

Kirkpatrick returned to Madeira and "discovered" nummulites in the igneous rocks there as well. I can scarcely imagine a more radical claim about the earth's structure. Igneous rocks are the products of volcanic eruption or the cooling of molten magmas within the earth; they cannot contain fossils. But Kirkpatrick argued that the igneous rocks of Madeira and Porto Santo not only included nummulites but were actually made of them. Therefore, "igneous" rocks must be sediments deposited at the ocean bottom, not the products of molten material from the earth's interior. Kirkpatrick wrote:

> After the discovery of the nummulitic nature of nearly the whole island of Porto Santo, of the buildings, wine-presses, soil, etc., the name *Eozoon portosantum* seemed a fitting one for the fossils. [*Eozoon* means "dawn animal," more on him in a moment.] When the igneous rocks of Madeira were likewise found to be nummulitic, *Eozoon atlanticum* seemed a more fitting name.

Now, nothing could stop Kirkpatrick. He returned to London itching to examine igneous rocks from other areas of the world. All were made of nummulites! "I annexed in one morning for *Eozoon* volcanic rocks of the Arctic and in the afternoon of the same day those of the Pacific, Indian and Atlantic oceans. The designation *Eozoon orbis-terrarum* then suggested itself." Finally, he looked at meteor-

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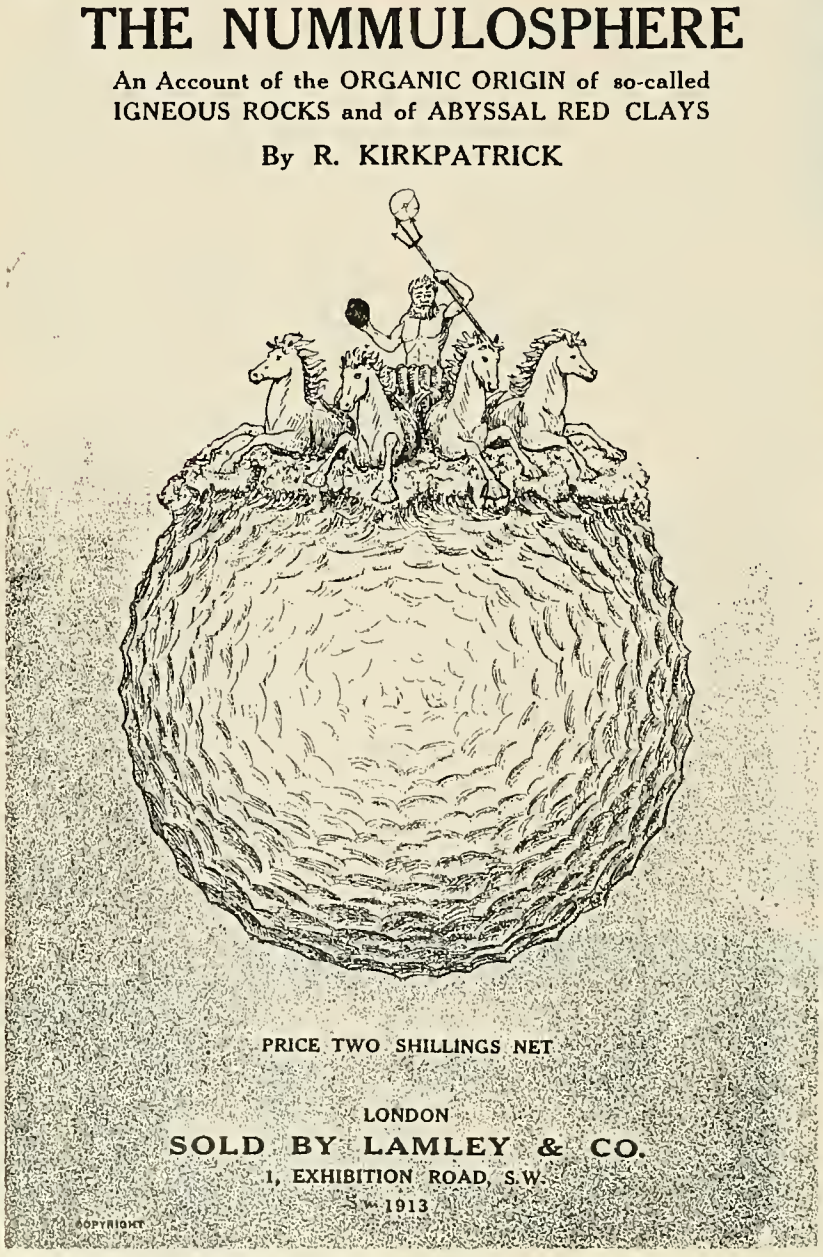
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ites and, yes, you guessed it, all nummulites:

If *Eozoon*, after taking in the world, had sighed for more worlds to conquer, its fortunes would have surpassed those of Alexander, for its desires would have been realized. When the empire of the nummulites was found to extend to space a final alteration of name to *Eozoon universum* apparently became necessary.

Kirkpatrick did not shy away from the evident conclusion: all rocks on the earth's surface (including the influx from space) are made of fossils: "The original organic nature of these rocks is to me self-evident, because I can see the Foraminiferal structure in them, and often very clearly indeed." Kirkpatrick claimed that he could see the nummulites with a low-power hand lens, although no one ever agreed with him. "My views on igneous and certain other rocks," he wrote, "have been received with a good deal of skepticism, and this is not surprising."

I hope I will not be dismissed as an establishment dogmatist if I state with some assurance that Kirkpatrick had somehow managed to delude himself. By his own admission, he often had to work very hard in toeing his own line: "Sometimes I have found it necessary to examine a fragment of rock with the closest scrutiny for hours before convincing myself that I have seen all the above-mentioned details."



But what version of the earth's history would yield a crust made entirely of nummulites? Kirkpatrick proposed that nummulites had arisen early in the history of life as the first creatures with shells. Hence, he adopted for them the name *Eozoon*, first proposed in the 1850s by the great Canadian geologist Sir J. W. Dawson for a supposed fossil from some of the earth's oldest rocks. (We now know that *Eozoon* is an inorganic structure, made of alternating white and green layers of the minerals calcite and serpentine.)

In these early times, Kirkpatrick speculated, the ocean bottom must have accumulated a deep deposit of nummulitic shells over its entire surface, for the seas contained no predators to digest them. Heat from the earth's interior fused them together and injected them with silica (thus solving the vexatious problem of why "igneous" rocks are silicates, while nummulites are made of calcium carbonate). As the nummulites were squeezed and fused, some were pushed upward and tossed out into space, later to descend as nummulitic meteorites.

Rocks are sometimes classified as fossiliferous and unfossiliferous, but all are fossiliferous. . . . Really, then, there is, broadly speaking, one rock. . . . The lithosphere is veritably a silicated nummulosphere.

Kirkpatrick still was not satisfied. He thought he had discovered something even more fundamental. Not content with the earth's crust and its meteorites, he began to see the coiled form of nummulites as an expression of life's essence, as the architecture of life itself. Finally, he broadened his claim to its limit: we should not say that the rocks are nummulites; rather, the rocks and the nummulites and everything else alive are expressions of "the fundamental structure of living matter," the spiral form of all existence.

Nutty, yes (unless you feel that he had intuited the double helix). Inspired, surely. A method to his madness, yes, again—and this is the crucial point. In framing the nummulosphere theory, Kirkpatrick followed the procedure that motivated all his scientific work.



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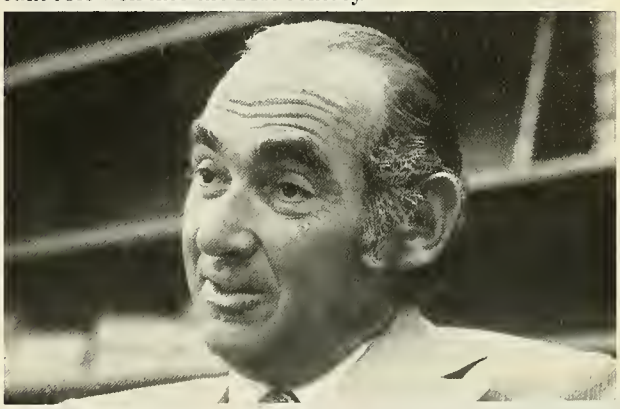
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continued...

"Clean-burning, easily-transportable gas will play a significant role well into the 21st century."





"...even with an electric heat pump, the cost of heating with coal gas will still be less than with electricity."

HUGH DOWNS:
Do we really have to wait that long?

DR. LINDEN:
There are essentially three reasons why I cannot give you a simple answer. The first reason is technological. The second financial. The third environmental.

Let's talk about technology first. Processes for gasifying coal into *medium* Btu gas have been commercially available for many years. They have now been adapted to the production of *high* Btu gas—SNG. Those are first generation technologies.

In order to get the enormous cost of construction down and to reduce requirements for land, water and labor, the gas industry and the government are developing new second generation technologies. Because of the urgency, several different processes are being developed simultaneously. One of these is the HYGAS process on which we have been operating a pilot plant here in Chicago since 1972.

HUGH DOWNS:
Isn't gasification basically a simple process? I mean for a society that's been to the moon?

DR. LINDEN:
Yes, basically. What's involved is adding hydrogen to coal, and the best source of hydrogen is water or steam. However, to do this efficiently requires high pressures and high temperatures and that means quite expensive equipment. So while the process is quite simple, the various complex steps to make it environmentally-sound and efficient on a commercial scale require very high investments.

HUGH DOWNS:
How much gas would a full-sized plant produce?

DR. LINDEN:
Commercial plants now in the design stage will produce 250 million cubic feet of SNG a day, using about 20,000 tons of coal and 7 million gallons of water in the process. However, just one plant will produce enough gas to serve as many as 700,000 residential customers.

HUGH DOWNS:
How much would a plant like that cost?

DR. LINDEN:
About $1.3 billion in today's dollars. If we wait, of course, the cost will go up because of inflation.

HUGH DOWNS:
And you don't think we should wait for some technological breakthrough that would greatly enhance efficiency?

DR. LINDEN:
I don't. I think last winter's emergency illustrated the urgency to start building plants using existing technology.

HUGH DOWNS:
How many gasification plants are currently planned?

DR. LINDEN:
Six have been announced, most of them in the Western U.S. These are all based on what is called the Lurgi process.

HUGH DOWNS:
But no one has started construction yet?

DR. LINDEN:
That's right. The biggest obstacle to building plants on a commercial scale today is financing. Because of the enormous capital requirements for each coal gasification project, lenders are simply unwilling to rely on gas companies alone to provide the credit assurances they demand.

HUGH DOWNS:
Are you saying that gas made from coal will cost more than natural gas?

DR. LINDEN:
Yes. When you're discussing coal gas of pipeline quality, you're looking at roughly four dollars per thousand cubic feet. Customers aren't used to that. They're buying natural gas cheaper today.

HUGH DOWNS:
How could you sell it then?

DR. LINDEN:
Well, there are some who feel that any supplemental source of energy should be priced at its true cost in order to signal that it's expensive. Much more expensive than what we've been used to. However, most of us in the gas industry feel that it would be fairer to price supplemental gas on a rolled-in basis—in other words, average it in with other, lower-cost supplies. In fact, oil and electricity have been priced this way for years.

HUGH DOWNS:
Setting aside any environmental cost considerations for the moment, how does the cost of coal gasification compare with coal-fired electricity?

RESIDENTIAL ENERGY PRICE CALCULATION

(1976 DOLLARS)

	Coal Gasification	Coal Electricity with Scrubbers
Capacity	250 mill cu ft/day	3,000 megawatt
Annual Generation	91.3 billion ct	18,936 gigawatt
Capital Cost	$1.3 billion	$ 2.7 billion
Production Cost (/million Btu)	$3.30	$ 8.95
Transmission & Distribution Cost (/million Btu)	$1.15	$ 4.82
Delivered Cost (/million Btu)	$4.45	$13.77
Cost to consumers (/useful million Btu based on appliance efficiency)		
With conventional appliances	$7.00 (approx.)	$14.00 (approx.)
With heat pumps	$4-5.00 (approx.)	$7-10.00 (approx.)

Based on recent estimates, capital investment requirements for a western coal gasification plant delivering 250 million cubic feet per day are roughly half that of a coal-fired electric facility delivering a comparable quantity of energy to end-users. Even with the higher efficiencies of advanced electric appliances, such as heat pumps, consumer energy costs are still lower with gas.

DR. LINDEN:
Very favorably. The main reason is that it's so much more capital-efficient. On the production end, a coal gasification plant requires only about one-half the investment of a coal-fired power station. The advantage is even greater for transmission and distribution.

A recent study projects the consumer's cost of energy from coal gas versus coal-fired electricity for residential uses: clothes-drying, water-heating and space-heating. It shows the cost of energy from coal gas substantially lower than that of electricity. When it comes to cooking, gas also has an advantage.

HUGH DOWNS:
What about technological advances like the electrical heat pump?

DR. LINDEN:
Even with an electric heat pump, the cost of heating with coal gas will still be less than the cost of heating with electricity made from coal. With the new gas equipment under development this advantage would increase. But this is not a gas vs. electricity issue. Our country will need all the electricity, all the gas and all other clean and reliable energy sources it can get.

ENVIRONMENTAL IMPACT—EQUIVALENT PROJECTS

	High-Btu Coal Gasification Plant (250 million cu ft per day)	Electric Power Plant (3000 megawatt with scrubbers)
Air Emissions (lb/hr)		
Particulates	180	1,070
Sulfur dioxide	450	4,300
Nitrogen oxides	1,780	20,830
Carbon monoxide	90	1,200
Hydrocarbons	30	360
Water Requirements (Acre-ft/yr)	6,300	54,300
Solid Wastes (Tons/day)	1,400	5,100

Sources: Study prepared for the Council on Environmental Quality and the FEA, August 1975.
Final Environmental Impact Statement on the Proposed Kaiparowits Project, U.S. Department of the Interior, March 1976.

The environmental impact of substituting coal for oil and natural gas by means of producing high-Btu gas from coal at the mine mouth and delivering it through the existing gas pipeline system will be less than that of any other method of substitution.

HUGH DOWNS:
Let's move on to the third problem you mentioned—the impact on the environment.

DR. LINDEN:
That's actually another thing in favor of coal gasification. Much of our coal has a high sulfur content, which is environmentally unacceptable today when you burn it directly. But you release little sulfur into the air when you gasify coal.

HUGH DOWNS:
How about the desulfurization of coal for generating electricity? I know it's expensive now, but isn't that technology likely to be improved too?

DR. LINDEN:
Very likely. But you'll be interested to know that one possibility to lick the problem is to turn high-sulfur coal into a medium Btu gas and use it to produce electrical power. It may turn out to be the cheapest way to make such coal acceptable.

HUGH DOWNS:
Will gas have a future role to play when renewable energy sources, such as solar or fusion come into the picture?

DR. LINDEN:
Definitely. Gas energy will be around for a long time. And even gas can be renewable. Take hydrogen. Eventually it may replace today's gas in our pipelines. It's an ideal fuel and totally non-polluting.

HUGH DOWNS:
Let me see if I can recap. I'll start with the advantages of coal gasification.

There's an enormous amount of coal in the ground. It's our coal. We're not dependent on other countries. And gasification is environmentally acceptable.

DR. LINDEN:
I would add another advantage. Using coal instead of imported oil helps our critical balance-of-payments problem.

HUGH DOWNS:
Now the disadvantages. It's expensive to gasify coal.

DR. LINDEN:
No question about it. But I believe it'll be far cheaper than any other uses of coal for most consumer needs—certainly for the residential and commercial markets.

HUGH DOWNS:
Then there's the problem of raising capital. And last, even though gasification minimizes emissions into the atmosphere, there is still an environmental concern. Each plant uses prodigious amounts of land and water.

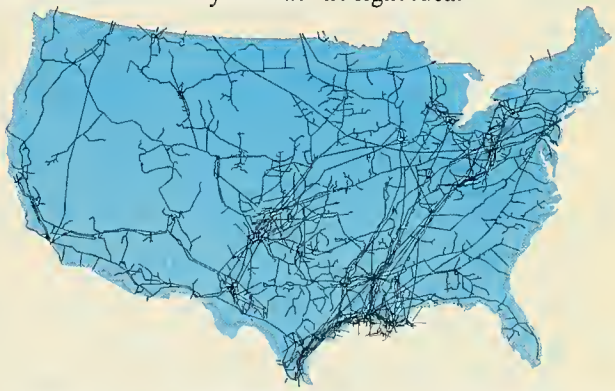
One last question. We haven't talked about conservation, which everybody agrees can play a really significant role in helping to close the gap between demand and supply.

DR. LINDEN:
Absolutely. Along with the development of new gas supplies, there's an urgent need to conserve—not to waste gas, or any other energy source for that matter. But while conservation is important, it alone won't close the gap. The reason we need more gas is that natural gas meets so many of our energy needs so perfectly. Because of that, it heats 55 percent of our homes and supplies 40 percent of the energy used by industry.

The truth is, America can't do without it, and we don't have to. Clean-burning easily-transportable gas will play a significant role well into the 21st century.

HUGH DOWNS:
So grandmother was ahead of her time?

DR. LINDEN: Let's say she had the right idea.



Built at a cost of $50 billion, the U.S. gas transmission and distribution network of one million miles is one of the most efficient methods to transmit energy.

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He had a passion for synthesis and an imagination that compelled him to gather truly disparate things together. He consistently sought similarities of geometric form among objects conventionally classified in different categories, while ignoring the ancient truth that similarity of form need not designate common cause. He also constructed similarities out of his hopes, rather than his observations.

Still, an uncautious search for synthesis may uncover real connections that would never occur to a sober scientist (although he may be jostled to reflect upon them once someone else makes the initial suggestion). Scientists like Kirkpatrick pay a heavy price, for they are usually wrong. But when they are right, they may be so outstandingly right that their insights beggar the honest work of many scientific lifetimes in conventional channels.

Let us return then to Kirkpatrick and ask why he was on Madeira and Porto Santo in the first place when he made his fateful discovery in 1912. "In September 1912," he writes, "I journeyed to Porto Santo via Madeira, in order to complete my investigation of that strange organism, the sponge-alga *Merlia normani*." In 1900, a taxonomist named J. J. Lister had discovered a peculiar sponge on the Pacific islands of Lifu and Funafuti. It contained spicules of silica, but had an additional calcareous skeleton bearing a striking resemblance to some corals (spicules are the small, needlelike elements forming the skeleton of most sponges). A sober man, Lister could not accept the "hybrid" and conjectured that the spicules had entered the sponge from elsewhere. But Kirkpatrick collected more specimens and correctly concluded that the sponge secretes the spicules. Then, in 1910, Kirkpatrick found *Merlia normani* on Madeira, a second sponge with siliceous spicules and a supplementary calcareous skeleton.

Inevitably, Kirkpatrick unleashed his passion for synthesis upon *Merlia*. He noticed that its calcareous skeleton resembled several problematic groups of fossils usually classified among the corals—the stromatoporoids and the chaetetid tabulates in particular. (This may seem like a small issue to many, but I assure you that it is a major concern of all professional paleontologists. Stromatoporoids and chaetetids are very common as fossils; they form reefs in some ancient deposits. Their status lies among the classical mysteries of my field, and many distinguished paleontologists have spent entire careers devoted to their study.) Kirkpatrick decided that these and other, enigmatic fossils must be sponges. He set out to find spicules in them, since spicules are a sure sign of affinity with sponges. Characteristically, he soon claimed that he had found spicules in all suspected groups. We may be quite sure that he had deluded himself again in some cases, for he included among his "sponges" the undoubted bryozoan *Monticulipora*. In any case, Kirkpatrick soon became preoccupied with his nummulosphere theory. He never published the major treatise that he had planned on *Merlia*. The nummulosphere made him a scientific pariah, and his work on coralline sponges was pretty much forgotten.

Kirkpatrick worked the same way in studying both nummulospheres and coralline sponges: he invoked a similarity of abstract, geometric form to infer a common source for objects that no one had thought to unite, and he followed his theory with such passion that he eventually "saw" the expected form, even where it manifestly did not exist. Yet, I must note one major difference between the two studies: Kirkpatrick was right about the sponges.

During the 1960s, Thomas Goreau, late of the Discovery Bay Marine Laboratory in Jamaica, began to explore the cryptic environments of West Indian reefs. These cracks, crevices, and caves contain a major fauna, previously undetected. In one of the most exciting zoological discoveries of the last twenty years, Goreau and his colleagues Jeremy Jackson and Willard Hartman showed that these habitats contain numerous "living fossils." This cryptic community seems to represent an entire ecosystem literally overshadowed by the evolution of more modern forms. This community may be cryptic, but its members are neither moribund nor uncommon. The linings of caves and crevices form a major part of modern reefs. Before the advent of scuba diving, scientists had been unable to study these areas.

Two elements dominate this cryptic fauna: brachiopods and Kirkpatrick's coralline sponges. Goreau and Hartman described six species of coralline sponges from the fore-reef slope of Jamaica's reef. These species are the basis for an entire new class of sponges, the Sclerospongiae. In the course of their work, they rediscovered Kirkpatrick's papers and studied his view on the relationship between coralline sponges and the enigmatic fossil stromatoporoids and chaetetids. "Kirkpatrick's comments," they write, "have led us to compare the coralline sponges described above with representatives of several groups of organisms known from the fossil record." They have shown, quite convincingly I think, that these fossils are indeed sponges. A major zoological discovery has solved an outstanding problem in paleontology. And crazy old Randolph Kirkpatrick had known it all along.

When I wrote to Hartman to inquire about Kirkpatrick, he cautioned me not to judge the man too harshly for his nummulosphere, for his taxonomic work on sponges had been sound. But I respect Kirkpatrick both for his sponges and his numinous nummulosphere. It is easy to dismiss a crazy theory with laughter based on no attempt to understand a man's motivation—and the nummulosphere is a crazy theory. I find that few men of imagination are not worth attention. Their ideas may be wrong, even foolish, but their methods often repay a close study. Few honest passions are not based upon some valid perception of unity or some anomaly worthy of note. The different drummer often beats a fruitful tempo.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

ERRATA: Please note the following corrections in the picture captions accompanying William Cade's "Of Cricket Song and Sex," January 1978. A species of round-headed katydid, not a tree cricket, is shown on pages 64–65. The long-legged crickets on pages 68–69 live on the ground, not in trees. The pink bases on the antennae of the insect on pages 72–73 identify it as a broad-winged tree cricket (*Oecanthus latipennis*), not a snowy tree cricket.



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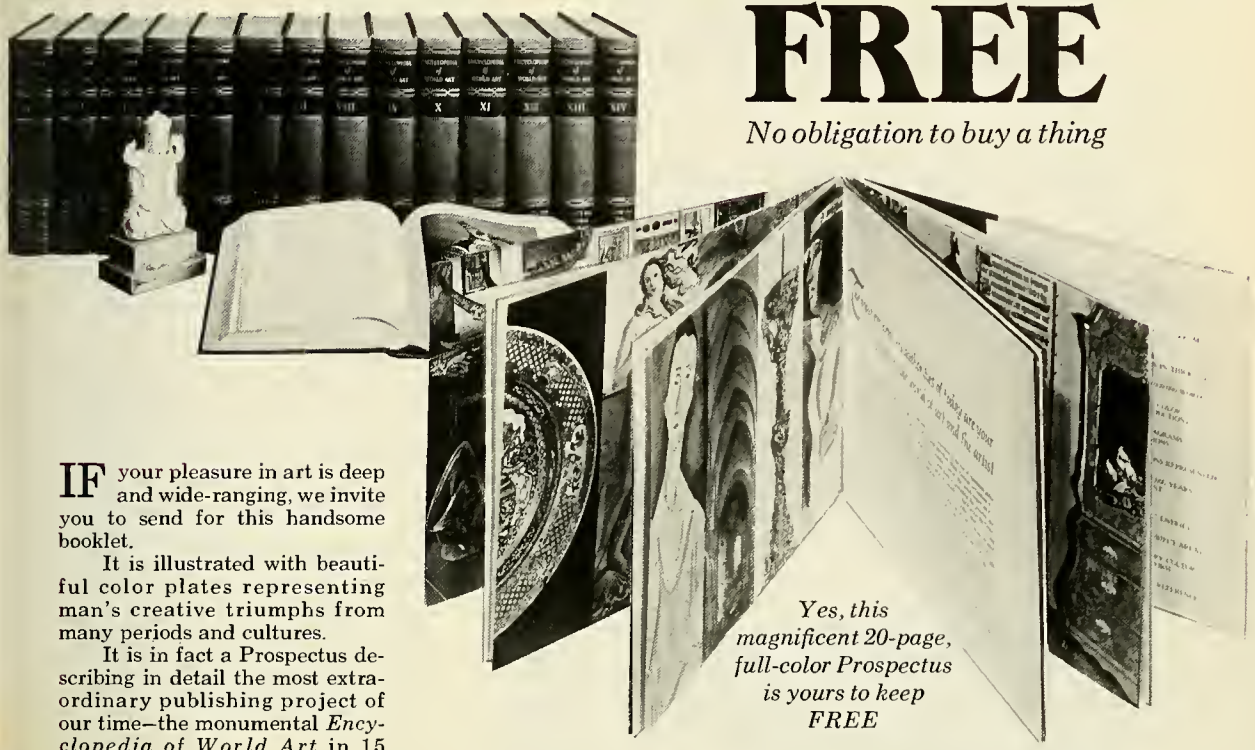
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In 1973, when the OPEC oil embargo went into effect, the Bell System committed itself to reducing its energy consumption. That commitment has been fulfilled. In four years, the Bell System has saved the energy equivalent of almost 24 million barrels of oil and over 415 million dollars in energy costs—savings that help hold down the cost of your telephone bills.

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Telephones are reconditioned three times.

The Bell System's energy needs begin with the power and fuel necessary to design and manufacture the basic communications components—cables, wire and equipment such as your home telephone.

In general, it takes much more energy to manufacture such items from scratch than it does to recycle them. Because Bell System equipment is designed by Bell Labs to be reliable, repairable *and* recyclable, extensive energy cutbacks have been realized through 40 years of recycling and reuse. New, more energy-efficient processes are constantly being devised by Western Electric, some of which entail modifying original designs for even greater materials and power savings.

Since 1974, the Bell conservation program has saved the energy equivalent of over three million barrels of oil by recycling metals. Also, more than six million equivalent barrels of oil have been saved through the reuse of equipment. The average telephone, for example, is reconditioned three times before it is unrepairable or obsolete.

New technology does more with less.

Another area in which the Bell System is effecting energy savings is in power for switching and transmission equipment. Constantly, new energy-saving technology is being added to the system. *Item:* Over two billion power-saving transistors, diodes and integrated circuits have been put into use. *Item:* Light Emitting Diodes (LEDs) are replacing incandescent bulbs in switchboards and telephones, saving over 90 per cent of the previously required power. *Item:* A new

microprocessor called MAC-8 is less than one-tenth the size of a postage stamp yet contains the equivalent of over 7,000 transistors. The MAC-8 can execute several hundred electronic "thinking" functions, yet it will operate on only one-tenth of a watt of power.

Smaller vehicles power giant fleet.

Twenty-two per cent of Bell's energy requirements are in fuel for its fleet of over 170,000 vehicles, the largest privately owned and operated motor fleet in the world. Here, a number of commonsense procedures have been adopted: engines are carefully tuned for peak efficiency, smaller and more fuel-efficient vehicles are being used, and shuttle services have been set up between some company locations. In addition, New York Telephone Company is experimenting with nonpolluting, energy-saving electric-powered trucks. Due to these and other efforts, the Bell System in 1976 used over five per cent less motor fuel than in 1973.

Even employees' body heat is used.

Heating, lighting and air conditioning of Bell System's 25,000 buildings account for 45 per cent of its energy needs. Broad economies have been achieved simply by removing thousands of unnecessary lights; by lowering temperature settings; by cutting back on hot water temperatures; and by heating or cooling unoccupied areas only to the extent required for equipment operations.

Moving beyond the obvious conservation measures, the Bell System created a building energy management program to redesign and retrofit existing buildings to improve their energy efficiency. Two examples of other power-saving programs at Bell facilities:

• On windy Block Island, Rhode Island, the New England Telephone Company began operating a wind dynamo in September, 1976. It can produce up to 15 kilowatts of electricity to power a central office and microwave radio terminal. Excess power from the windmill is fed back to the power company.

• In AT&T's new Basking Ridge, New Jersey, facility, an innovative computerized system heats about 1½ million feet of office space by recovering excess heat from the building environment—lights, equipment and the body heat of employees. It is estimated that the system uses 25 per cent less energy than conventional heating/cooling systems.

Bell trials of solar heating and cooling are providing valuable data which should lead to more widespread use of alternate energy systems.

Windmill helps power central phone office and microwave radio terminal (tower at right) on Block Island.



Today, throughout the Bell System, our commitment to energy conservation is more than a goal; it is an ongoing reality. And in looking to the future, we anticipate that in 1982 we will still be using no more energy than was used in 1973. *Keeping your phone system the best in the world.*

Bell System

A Nudge from the Hand of God

by Stephen Pastner

An anthropologist learns that Allah sees all on the coast of Pakistan

The pye-dog had been in agony for three days. While attacking a goat, it had been blinded by a stone that one of the fishermen had casually tossed. Its initial howls of pain had subsided, but as it roamed restlessly up and down the beach at night, its fretful moans carried through the flimsy plank walls of the reed-roofed, one-room shack where I lived with my wife and small daughter. On the third day, the dog sought the shade beneath one of the lateen-sailed boats on the beach. Since stronger members of the village pye-dog pack had driven the helpless animal from the piles of fish offal on which they fed, it was too weak to do more than whine and snap when the local children darted by or pitched sand at it. My wife and I were studying this Baluchi fishing village on Pakistan's Sind coast, which extends from the Indian border to northwest of Karachi, and since my primary concern was making observations, not value judgments, I had been trying, with some effort, to regard the dog's plight and the villagers' reaction simply as data. After all, the incident was a paradigm of behavior I frequently saw on my numerous trips to sea with the fishermen, as well as in other areas of village life.

During the men's sea hunts for fish, their livelihood, they often used such phrases as *khoda-i-dast* ("the hand of God"), *kismet* ("fate"), *Allah malik* ("God is the master"), and *Allah dant, na dant* ("God gives or withholds"). When a valued gill net, which had cost much money and labor, snagged on a Karachi shrimp trawler's propeller, the disappearance was "God's will." When a fishing ground that had for several days provided rich catches of Spanish mackerel suddenly yielded nothing but a rotting croaker, the reason was "fate." When for days on end, rioting in Karachi, precipitated by the ill-fated 1977 elections, closed roads to the city's fish markets and bazaars, the loss to the village economy was the "hand of God."

Many observers of the East have construed such apparent equanimity in the face of trouble as "Oriental fatalism," the view that this life and its capriciousness is but an illusory purgatory through which man must pass before reaching higher planes—the Buddhist "nirvana," the Hindu "moksha," or the "paradise" of Muslims such as the Baluch. Although I had learned to look for the logic and function beneath all social behavior, no matter how different from my own, I was often struck by the blasé air with which the village fishermen faced assorted trials.

Their unconcern over previous misfortunes sometimes seemed to carry over into a lack of foresight. The men did all their offshore fishing from sailboats twelve to forty-five feet long. Many were quite old, with hulls carved from single trunks of mango trees; some had been imported from south India as early as the turn of the century, in what the villagers called "Victoria's time." All were leaky, even the newer, planked boats. Fishing went on daily in waters where various shark species, ranging from toothless dogfish to sixteen-foot tiger sharks and large makos, were among the largest single items of catch. Since only preadolescent children generally swim for recreation, many of the men had forgotten how to swim. Yet the villagers never used safety equipment although it was available in Karachi, only twenty miles away. This insouciance was of some personal concern to me, since I frequently sailed as crew on various boats. If my host scorned life jackets, I felt morally obliged not to protect myself with such trifles. But after I almost capsized on my first trip out, the thought of another seven months of near-misses was not altogether pleasing.

The fishermen also seemed to have an insouciant attitude toward the dying dog, as they sat mending their nets a few feet away. When I asked if no one would put it out of its misery, I was told: "God will take it in His own time just as He has cared for it so far." (The latter was certainly true: the pye-dog pack passed their entire lives without any care from the villagers.) Another man elaborated, "We would be damned if we interfered with God's plan."

But I knew perfectly well that despite their verbal professions of fatalism, the Baluch hardly went through life as passive bystanders. The origin of their very way of life was testimony to an elemental refusal to knuckle under to fate. The ancestors of most of the villagers we studied had come from Baluchistan's interior, where they had been nomads and farmers. Some had been driven to the coast by droughts and the death of their flocks. Religious persecution forced others to flee desert life, for the fishermen in our village were Zikri, a sect brought to Baluchistan sometime in the late fifteenth or early sixteenth century by a wandering Muslim holy man from India. He preached belief in a Mahdi, an Islamic Messiah named Nur Pak, or "Pure Light," who supposedly was created before Adam. He will return with the Apocalypse, and his teachings are said to supersede those of Muhammed himself. To the Sunni Muslims of Baluchistan, such belief is heresy, and in the mid-eighteenth century, the khan

of Kalat, whose dominions included all of what is now Pakistani Baluchistan, declared a jihad, or holy war, against the Zikris, whom he considered infidels. To escape the khan, many Zikri Baluch fled south to the inhospitable coast of Baluchistan or southeast to Sind.

Whatever the cause of the Zikris' migrations from the interior, their transition from desert dwellers to fishermen was not easy. They had to learn new skills, master new environments. They would hardly have made these efforts if they had been mired in fatalism. Denying the teaching of their Mahdi and professing conversion to Sunni Islam would have afforded many Zikris easy escape. But the ancestors of the fishermen we knew had withstood this temptation, and those whose forebears had succumbed were disdained as apostates.

In everyday life, too, the fishermen's actions regularly belied their constant verbal bowing to God's will and destiny. Aside from the obvious hazards of deep-sea fishing from their crude craft, many fishermen were also involved in smuggling and used their sailboats to ferry contraband—usually gold and watches from the Persian Gulf states—from motor launches moored offshore to markets in Karachi. Occasionally, military helicopters looking for catches other than fish would hover over fishing boats as they unloaded. Then there was the regular practice of young village men uprooting themselves from their friends and families for months, and sometimes years, to try to make their fortunes in the Arab oil sheikdoms.

Seen against this background of risk and adventure, the villagers' professed fatalism became a courageous people's means of gracefully accepting what they could not change. Thus, when two of my closest friends lost newborn



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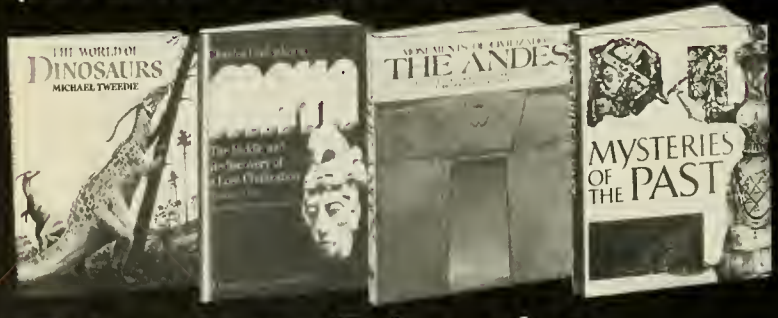
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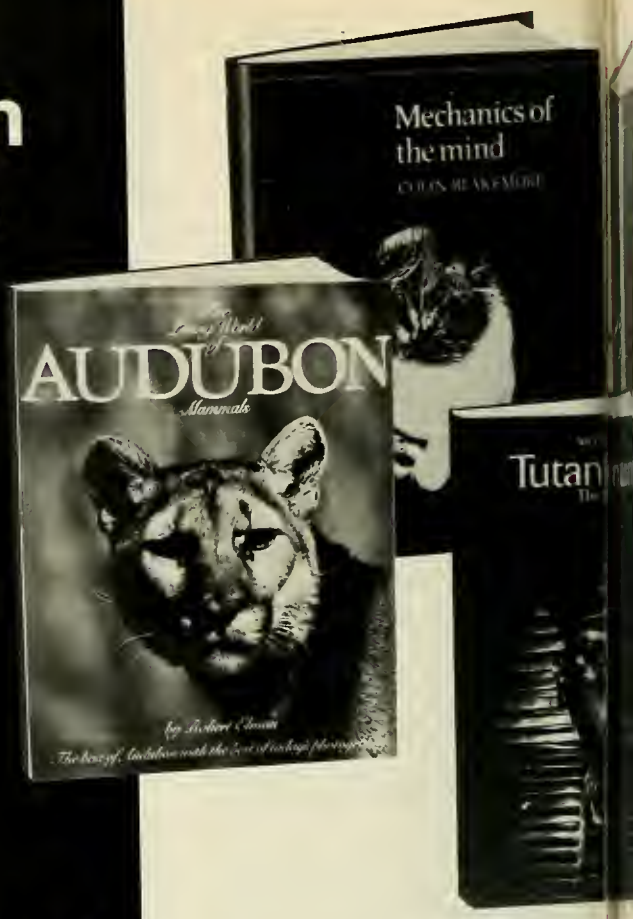
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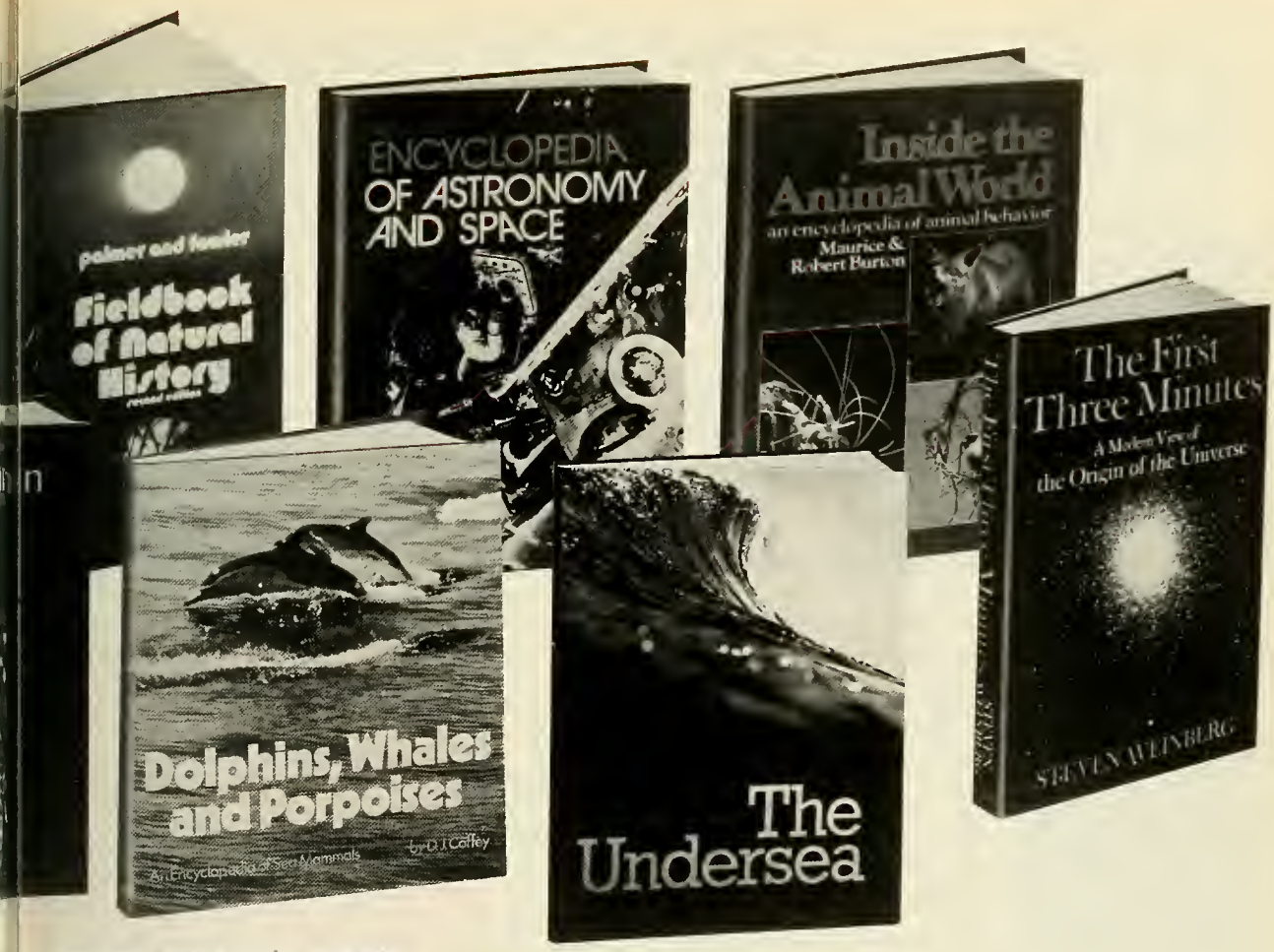
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babies on the same day—children they had wanted and had tried desperately to save by calling on all possible sources of medical and spiritual help—I could understand why they stood dry-eyed at the tiny graves and tried to ease my distress by saying, "After all we hardly knew them."

When I took a long view of the villagers' experiences, I sometimes noticed a kind of balance that validated the Baluchi idea of God's control over the universe. I recall one long day when our nets came up empty and the wind was so weak that we had to row most of the fifteen miles back to shore. Allah lessened our hardship by opening up what our captain referred to as the "sea bazaar." Our route took us through the sea lanes used by heavy international shipping en route to Karachi, and shortly, the wastefulness of sailors from the industrialized world became a boon for the Baluch. We fished from the water two edible oranges; a slightly moldy loaf of bread; a beer can, which with a few wrenches of a scaling knife became a durable drinking cup; and a good oak plank that was later made into a spare rudder. The captain then jokingly ordered us to keep watch for a floating prostitute to round out our haul.

Yet despite ample demonstrations of ways in which the Baluch braved their often difficult life, the matter of the dog rankled. I still found myself irritated by the local logic, which held that while the dog's blinding by the fisherman and teasing at the children's hands was no crime, putting it out of its misery was a damnable offense. So when several of the men came to me and—out of earshot of the others—urged me, an unbeliever anyway, to kill the animal, I quickly crushed its head beneath one of the massive log rollers used to beach boats. My act sparked a debate that continued for days in informal councils along the beach. Was I damned or had I provided a merciful cure for the dog's agony? The balance of opinion was against my act, and even my supporters thought I would be wise to make a *herat*, or offering to God, arguing that if Allah was angry, I'd be propitiating Him; and that if He was unperturbed, I had nothing to lose. Before I got around to doing anything about the *herat*, I was given a personal demonstration of the long arm of Allah in human affairs, and learned new appreciation of Baluchi awareness of the divine presence.

Besides studying the fishermen's social organization and cultural ecology, I was interested in the beliefs and rituals of the Zikri sect. I frequently sat in on their prayer sessions (zikr) which differ markedly from those of Pakistan's orthodox Sunni Muslim majority. During a zikr, fishermen praise God and their Mahdi in chants with beautiful, intricate contrapuntal harmonies that I found deeply moving. After nearly seven months of intimate association with the village, I finally obtained permission from the resident mullahs (religious leaders), as well as from a visiting Zikri *pir*, or saint, to tape-record a Thursday night zikr. (Like many other Muslims, Baluch revere saints, who may be dead or still living.)

My tape recorder, which I periodically borrowed from an anthropologist friend in Karachi, was a welcome addition to village life on other occasions. Men were always eager to perform *hambas*, or net-hauling chanteys, and other secular material for my microphone. But when I wanted to introduce the machine into the village zikr khana, the cinderblock and stucco house of prayer, some men were dubious. The zikr khana was supposed to be a place of purity, uncontaminated by worldly goods. For visits to the zikr khana, fishermen, who spent much of their work day amidst offal and the stench of drying fish, bathed and dressed in clothes of purest white, covering their heads with diaphanous prayer shawls. I always left even my eyeglasses outside this holy place, into which I now wanted to take a profane piece of machinery.

On the night of the recording, I tested and retested the machine, which had always worked perfectly. (It was a simple casette model and not much could go wrong.) A number of men told me that God might not be too pleased with my project, but I advised them to relax, as the mullahs themselves had given approval.

The service began smoothly with the men in extraordinary voice. Any anxieties over the presence of a profane object had been overcome by devotion, and also, I suspect, by the prospect of performing for posterity. The early parts of the service rolled routinely onto the tape: the *la*, or repeated chanting of God's name, and the *shahdat* and *dwa*, prayers in praise of the Mahdi. But when those complex and lovely harmonies that I so wanted to preserve began, my machine's quiet whir suddenly stopped. Several bearded and shrouded heads turned imperceptibly toward me, and I could detect more than one owlish expression with an "I told you so" twinkle barely masked by ceremonial solemnity.

Chastened and unwilling to tempt fate, I made my overdue offering the next day, in the form of a financial donation to the zikr khana.

The Baluch occupy a small and remote part of a vast arid zone that has long been the breeding ground of prophets, the playground of jinn and other spirits, yet also witness to some of mankind's most rational and pragmatic achievements. The Baluch are latter-day heirs to this juxtaposition of empiricism and supernaturalism. Historically and theologically, the Zikri sect is a late offshoot of the medieval Sufis—the beggar mystics who, ecstatically reciting the name of God, relegated themselves to His care. But the sect's contemporary practitioners are husbands and fathers; sisters and mothers bound up in obligations to others and in a value system that esteems hard work, the person of "heart" or courage, and *izzat*, a notion of honor that is frequently aggressive. Total reliance on God is for spiritual virtuosos—like the *pir* and the fakir (a wandering mendicant)—who have extinguished worldly desire through single-minded devotion. Most Baluch cannot do this and know it; instead, they manifest their honor in a less exalted but equally difficult struggle for a livelihood in the desert or on the sea and in fulfillment of their duties as kinsmen and neighbors. Their theology takes the sting of personal blame from failure by acknowledging that all is ultimately in the hand of Allah. Blinded dogs notwithstanding, such belief is merciful even when the stern God of Islam is not.

Stephen Pastner is associate professor of anthropology at the University of Vermont.



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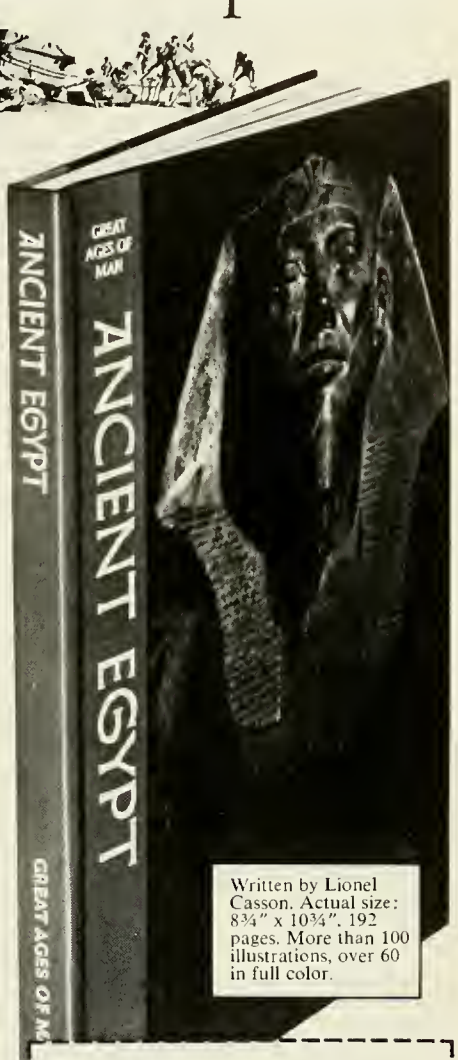
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by Michael Oppenheimer

What Are Comets Made Of?

If we could be certain of the answer, we would know more about where these objects come from and how they are formed

Comets are deceptive objects, disguising their true nature behind the filmy veil of light we see from the earth. A comet appears to the eye as a diffuse, somewhat V-shaped curtain of luminosity (the tail) attached to a brighter, rounded vertex (the head). The length of the tail and the brightness of the whole comet vary over a period of months, first increasing as the comet approaches the sun, then decreasing as its orbit takes it back into the outer solar system. The point of closest approach, or perihelion, is often much nearer to the sun than is the earth. The farthest point of the orbit may be as near the sun as the neighborhood of Jupiter or as far away as the edge of the solar system. When comets with the latter variety of orbit are observed, they are called "new comets." They have probably never previously entered the inner solar system, having remained at the edge of the system since before the birth of the sun.

What causes the glow of visible light from a comet? Is a comet composed of gases, liquids, or solids? What chemical compounds is it made of? These are some of the questions that occur immediately to anyone who has ever seen a comet. The first two questions have been answered satisfactorily by modern astronomers. The final question is currently a matter of intense debate and energetic investigation by a number of astronomers, physicists, and chemists. In this article, I shall attempt to summarize the present state of knowledge on the chemical composition of comets. But first, let us examine the information that has come to light in answer to questions one and two.

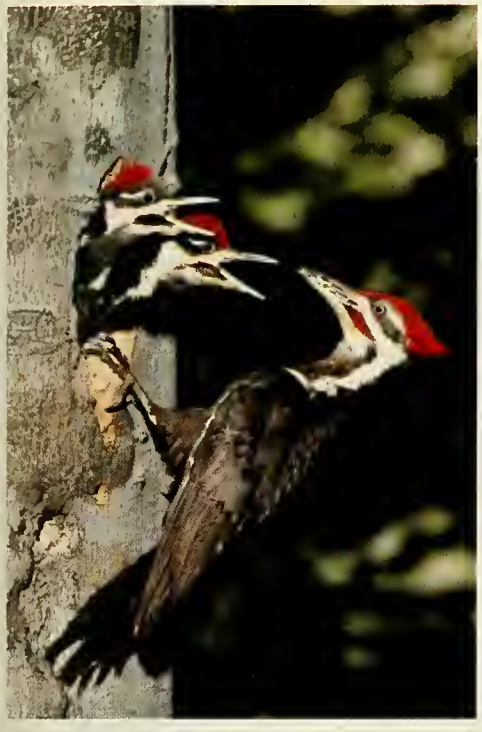
Astronomers obtained a detailed picture of comets by enlarging their images with telescopes and then breaking down the light into its component wavelengths with a spectrograph. What emerged was an incredibly complex pattern of spectral lines and continuum radiation. Let me explain the meaning of these terms. An atom or molecule in a gas may absorb radiation, such as sunlight, and thereby change the amount of its energy. It may subsequently reemit some or all of this energy. The wavelengths of radiation that can be absorbed or emitted in this manner are characteristic of particular atoms or molecules. A particular atom or molecule has many such wavelengths of radiation, generally known as spectral lines. When atoms or molecules aggregate in a dense body, their spectral lines tend to lose their individual character and merge into a broad emission spectrum called a "continuum." Visible sunlight, with its maximum intensity at wavelengths that appear to us as yellow, is an example of such a continuum.

The visible spectra of comets are characterized by both line and continuum emission. The continuum emission is identical to that coming to us from the sun. Since comets are too low in weight to create their own light, it is assumed that something in the comet acts as a mirror and reflects solar radiation. Gases, composed of individual atoms and molecules, do not have this reflection property, but aggregates, such as solids, do. Observations of radiation from comet Kohoutek with wavelengths longer than visible light (infrared radiation), have shown that the reflecting bodies are small dust grains, no larger than one ten-thousandth of a centimeter in diameter.

The spectra are so rich in emission lines in the visible region that many spectral pictures of comets have never been thoroughly analyzed. The presence of emission lines indicates that comets contain gas as well as dust. Seventeen gaseous atoms and molecules that have emission lines in the visible spectrum have been positively identified in comets. Most of the molecules are highly reactive and do not survive long on earth, although they can be artificially produced in a laboratory. Some of these are the carbon molecules C_2 and C_3, the nitrogen-hydrogen molecules NH and NH_2, the carbon-hydrogen molecule CH, and the water ion H_20^+.

Recent technological advances have permitted the investigation of cometary radiation at wavelengths both longer and shorter than those of visible light. Most wavelengths of ultraviolet radiation, which has a shorter wavelength than blue light, cannot be observed from the earth's surface due to absorption by atmospheric gases. Scientists surmounted this problem by using telescopes and spectrographs mounted on satellites or rockets that ascended above most of the atmosphere. The results were dramatic. Emission of radiation from atomic hydrogen was discovered for the first time, and it

Please turn to page 47





Lucky shots? Hah!

Pictures like these you don't get by strolling along whistling a tune and whipping out your camera now and then. Here, for example, is a hint of what it took to catch that pileated woodpecker tending her brood.

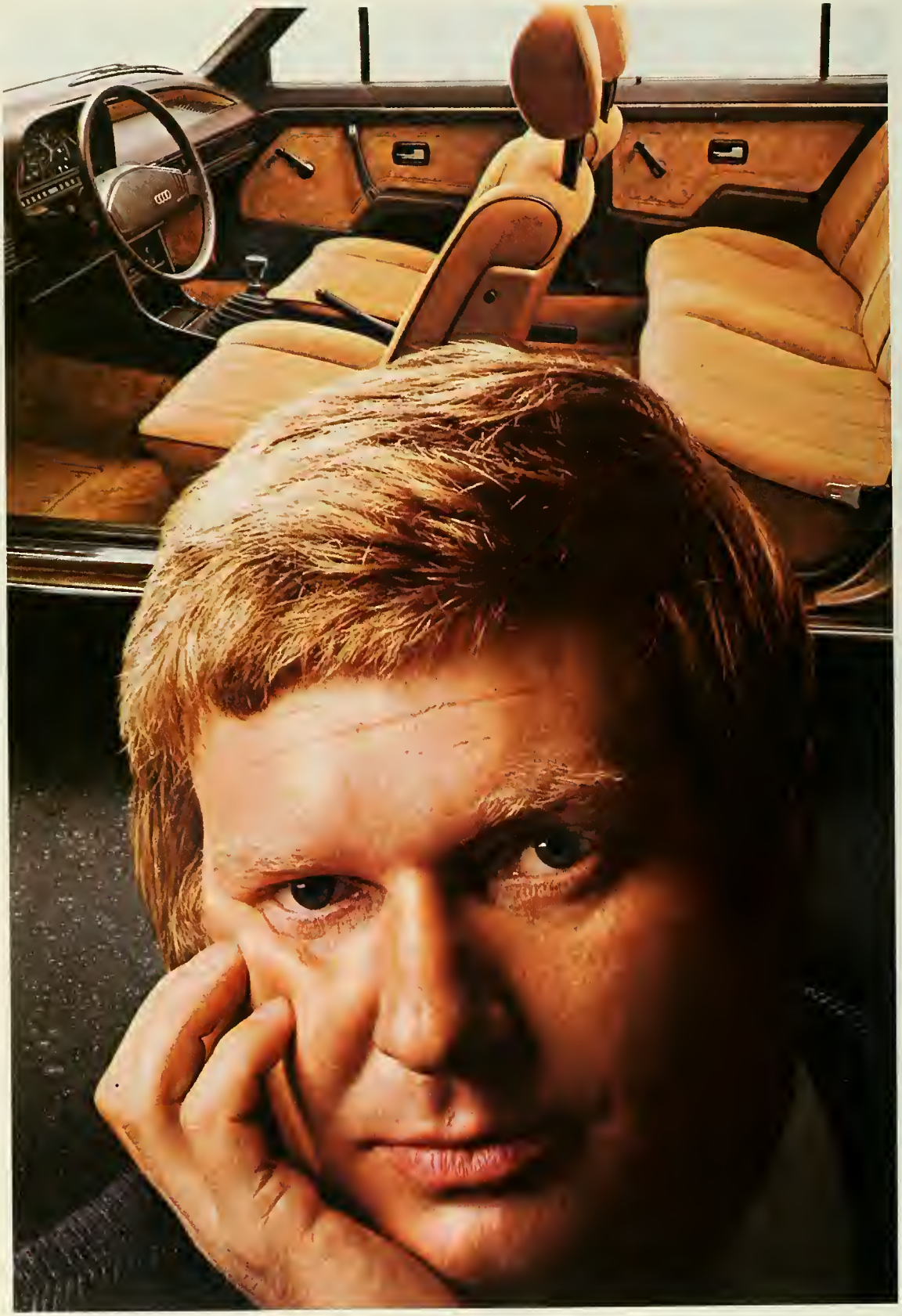


The bittern, freezing on her nest to blend in, was easier. Dick Robinson, our bird man, merely waited the days out until the eggs were about to hatch and her maternal juices suppressed her flight reaction.

Robinson, whose job with us is to tell Canadians how to get more out of their photography, has written a detailed and magnificently illustrated essay which leaves the impression that the way for a birder to understand wild birds and graduate from the numbers game of "life lists" is to photograph them. To follow his ingenious suggestions is most time-consuming, but they should prove inspiring to both the field biologist and those to whom time is given to be happily consumed. They appear in *The 10th Here's How,* Kodak Publication No. AE-110, available through photo retailers.

The book also contains how-to-do-it articles on photographing sports, crystal patterns by polarized light, wildflowers, nature trails, and attractive specimens of humanity in a home studio. Mr. Robinson would prefer you turn your mind to one of those themes if you know you are the type for whom getting your bird pictures could become as important as the subsequent welfare of your feathered subject with its task of perpetuating its own species.

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Warkusz: In some ways, yes. The old kind of interiors with stark black leather and polished chrome everywhere is no longer appropriate for today's cars. We wanted to create a more modern living environment inside the car. A car should be a pleasant, bright and comfortable place to be in. You should feel at home. Your living room at home isn't black all over, is it?

No. But my living room doesn't have wheels.

Warkusz: And we didn't just put wheels on a living room and so we didn't design the car only for the comfort of the driver. The Audi 5000 holds all 5 people comfortably. The trunk is huge enough to hold all their luggage.

The ventilating system is unique in that there are outlets to provide plenty of fresh air but not on anybody's neck. You can even have warm air on your feet and cool air on your face to keep you alert. For the sake of comfort and safety, the rear passengers have headrests, too. We have even gone so far as to be sure that the upholstery doesn't tear the fur out of a mink coat. Some fabrics we tested did just that.

Will this type of interior appeal to Americans?

Warkusz: We believe so, because we studied the American market very carefully. Not to copy, but to take American tastes into consideration. The Audi 5000 is altogether European, but there is no reason why a European car can't be bright and roomy and comfortable and quiet. A high performance European car does not have to look or sound like the cockpit of a plane.

The lines do look European.

Warkusz: Lines are not European or American. Lines can be ugly or beautiful, but most importantly, lines are functional or not functional. The aerodynamic values of the Audi 5000 make the air resistance very low. The drag coefficient is better than most other cars in our size category. Also, the aerodynamics made us lift up the tail of the car. That's one reason why the trunk came out so big.

For the same reason, we have complete instrumentation without two dozen unnecessary switches to distract the driver with playthings. I am glad you like the lines, but they are more than lines to me.

What would you want an American buyer to understand about it?

Warkusz: I would want him to understand the mature, functional design of the car. The pleasant, comfortable and quiet atmosphere of the interior. The high quality of the finish. And, the fact that it's the largest German car you can buy for the money—about $8,500.* And I would want the American buyer to understand that nothing about it is by chance.

*Suggested 1978 retail price $8450, P.O.E., transp., local taxes, and dealer delivery charges, additional



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was found that comets are surrounded by clouds of this gas in a huge sphere much larger than the comet head. This gas is not seen at visible wavelengths—and certainly not by the naked eye. These observations were first made in 1970. Identification of the spectral lines of other atoms and molecules at ultraviolet wavelengths soon followed, including lines characteristic of atomic carbon and carbon monoxide.

Where does the energy for these emission lines come from? Some sunlight is absorbed by cometary atoms and molecules and subsequently reemitted. Detailed studies of comet spectra support the conclusion that almost all the radiant energy from comets has its origin in sunlight.

With the passage of comet Kohoutek and other recent bright comets, the wavelength range of comet observations has been extended to include wavelengths longer than the visible. We have already mentioned the infrared region, where wavelengths range from a ten-thousandth of a centimeter to a hundredth of a centimeter. Emissions have also been seen at microwave wavelengths that are on the order of a centimeter long. Among the molecules whose spectral lines have been seen at these wavelengths is the rather complex methylcyanide molecule, heretofore also observed in clouds of gas in interstellar space. Many other molecules that have no significant visible emission lines will presumably be observed by microwave telescopes in the future.

Now that we have glanced at the spectroscopic information on comets, let us try to interpret it and attempt to unmask the nature of these familiar but obscure objects. The most fruitful theory of comet composition has been the "dirty iceball" theory devised by Fred Whipple, an astronomer at Harvard University. This theory states that the gas of molecules and atoms is formed as sunlight heats a solid nucleus of "ices," which measures about ten kilometers (six miles) in diameter, in a process known as sublimation. In other words, the nucleus is a frozen hunk of water ice, as well as the cold solids, or ices, of other chemicals such as methane, ammonia, and carbon dioxide.

Why are these species originally frozen? Because comets come from a region of space far from the sun, near Jupiter and beyond, where bodies have temperatures below the freezing points of these gases, perhaps below −200°C. As comets approach the sun, their nuclear surface is softened up by the heat of sunlight and gases escape into the surrounding space. The comet dust, which escapes with the gas, is made of heavier, more rocklike material such as oxides of silicon (related to sand)—hence the name "dirty iceball."

The nucleus is presumably located in the center of the comet head. If only sublimation were involved, the gas and dust would remain in a spherical head around the nucleus and comets would appear to be balls of light. But comets have a tail. Something pushes the gas and dust away from the head.

When bits of solar radiation, or photons, are absorbed by atoms, molecules, or dust particles, the absorption process resembles in some respects a collision between billiard balls. The photons are initially moving away from the sun, and when an atom, molecule, or dust particle absorbs the photon, the absorbing object "rebounds" away from the sun. Similarly, electrons and protons escaping from the solar surface in the solar wind also collide with the comet gas and cause it to rebound. The net effect is that atoms, molecules, and dust "tail" behind the comet nucleus.



Comet West

Dennis Di Cicco; *Sky and Telescope*

It takes a while from the time a particle leaves the nucleus to the time it has undergone enough of these collisions to be swept backward. Therefore, a region near the nucleus remains more or less spherically symmetric. The reflection of light from dust in this region is what gives the appearance of the head.

Finally, some comets actually have two tails because ions are pushed rapidly away from a comet's orbital path by the action of the magnetic field emanating from the sun. This leads to a visible "ion tail." The dust is much less strongly affected by magnetic fields. Thus it trails behind the head in a different direction from the ions. Comet tails can sometimes stretch tens of millions of miles across the sky, but the whole show is produced by a tiny nucleus that is only a few miles in diameter and contains much less mass than the earth. That is why Whipple has called comets "the greatest deceivers in the solar system."

The most important prediction of the dirty iceball theory is that molecules sublimating from the nucleus will absorb solar radiation as they stream outward in the head and that this absorbed energy will cause some of the molecules to fragment. One way the molecules may fragment is by splitting off one or more of their constituent atoms, a process called "photodissociation." Molecules may also fragment by ejecting an electron to form a positive ion in a process known as "photoionization." Thus the theory predicts that molecules that can form ices, or "parent molecules," as well as their fragments and ions, should be present in the head and be observable through the characteristic emission lines of each molecule, ion, or fragment.

A curious fact about the data on comets is that although emission lines of fragments and ions are observed, as previously mentioned, emission lines of reasonable candidates for parent molecules are generally not observed. There are three exceptions: a microwave emission line of water was tentatively identified in comet Bradfield one evening in 1974, and emission lines of hydrogen cyanide and methylcyanide were seen on several evenings from comet Kohoutek. The limited nature of these observations is surprising, considering that emission lines of hydrogen atoms, hydroxyl radicals, hydroxyl ions, and water ions—all fragments of water—are commonly observed in comets.

Similarly, observations hint that comets contain little or no ammonia or methane, even though their molecular fragments—nitrogen-hydrogen and carbon-hydrogen radicals and ions—are ubiquitous. Although part of the problem of the missing parent molecules is that atmospheric absorption interferes with the observation of many of their emission lines, they are still far more scarce than anticipated. If the expected parents aren't there, how is it their fragments are found in the comet head?

Three possible solutions have been advanced. One is that our observations are incomplete and eventually we shall observe water, carbon dioxide, and other parent molecules directly and in substantial abundance. Hence, most scientists still think that water is the best bet as one of the major comet molecules.

The second possibility is that parent molecules don't really exist and that the fragments themselves are sublimated from the nucleus. This is generally discounted because the fragments, especially the ions, are too reactive to be stored in the nucleus for very long.

The third possibility is the most intriguing. It is that the fragments are not generated by the parent molecules they most closely resemble. In other words, nitrogen-hydrogen, carbon-hydrogen, and hydroxyl radicals and ions may not arise directly from ammonia, methane, and water, but as products of chemical reactions involving other parent molecules and their fragments. In support of this theory is the fact that some fragments in the head, such as the carbon molecule C_3, cannot be made in abundance by any simple fragmentation process of a reasonable parent molecule but can be made by chemical reactions. Calculations have shown that chemical reactions will certainly be a dominant source of some fragments, although dissociation and ionization are undoubtedly the dominant source of others.

The new awareness of the importance of chemistry in the comet head may hasten a reinterpretation of the spectra of the fragment species. Such a study would provide an idea of the molecules that left the nucleus and subsequently underwent photoionization, photodissociation, and chemical reactions. The failure to observe some parent molecules may simply mean that we are looking for the wrong ones. It has even been suggested that some of the unseen parent molecules are closely related to the organic chemicals that constitute living things and that this material was deposited on earth after escaping the tail of a comet. Some scientists have speculated that these molecules may have been involved in the origin of life on earth.

We are still unsure about what molecules are present in comets, that is, what comets are made of. But the chemical approach is a significant step in the direction of solving this problem. Once we know what comets are made of, we will be better able to answer two other important questions: Where in the solar system do new comets come from? How are comets made?

How will we investigate comets in the future? One exciting possibility is that a space probe might be sent directly to a comet, either passing through it or flying alongside and perhaps docking with the nucleus. Samples of comet material would then be directly observable and might even be retrieved and returned to earth. Halley's Comet is a possible target for such adventures during its 1986 return. The impact on our knowledge of comets and of the solar system would be spectacular. If we probed a new comet, not only would the age-old question of comet composition be answered, but we would have in our hands material from the edge of the solar system, the portals of outer space. This material, probably undisturbed since before the birth of the earth and the sun, would contain a record of the far distant past, a time otherwise inaccessible except in our imaginations.

Michael Oppenheimer is affiliated with the Center for Astrophysics at Harvard College Observatory and the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts.

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Imperiled Bats of Eagle Creek Cave

by Michael G. Petit

photographs by Robert W. Mitchell

Mexican free-tailed bats face the twin threats of pesticides and harassment

Eagle Creek Canyon forms part of the southwestern drainage for Arizona's rugged Gila Mountains. The canyon is hot, arid, remote; and an ideal place for the Mexican free-tailed bat to give birth and rear young. Small moths and beetles are abundant in the nearby Gila River valley, within easy foraging range for the bats. Moths make up better than 50 percent of the bat's diet. Other locally plentiful prey are termites, leaf hoppers, flies, and night-flying wasps. Another—and crucial—attraction for the bats is a large cave in one of the canyon walls.

This cave, about a hundred feet above creek level, is entered through a large vertical slit that leads to a single, football-shaped chamber about 288 feet long, 65 feet wide, and 80 feet high. The bats roost in a 6-foot-wide crack that extends nearly one-third the length of the ceiling.

Mexican free-tailed bats are gregarious and their colonies have the highest population density of any mammal on earth. Two or three hundred can easily pack themselves into a square foot of ceiling space. Since they use the cave primarily for giving birth and rearing their young, the bats at Eagle Creek constitute a maternal colony. (Males make up only about 10 percent of the cave's bat population. The bulk of the males use other caves scattered throughout the surrounding area as roosting sites.) The bones of baby bats found in ancient guano deposits indicate that such cave-dwelling maternity colonies have had a long history.

The earliest known bat fossils date back to the Eocene (36 to 53 million years ago). Bats probably diverged from small mammals that lived in trees and foraged among the branches for insects. The development of a membrane between the fingers of these precursors of contemporary bats enabled them to leap farther after insects and scoop up their prey as modern species do. An echolocation apparatus also evolved as a mechanism for catching insects in the dark. Just how these adaptations evolved, and over what period of time, is not known, but together they enabled some ancestral bats to exploit an arboreal, and eventually an aerial, insectivore niche more efficiently. (Fruit- and fish-eating bats probably evolved from insectivorous species.)

The membrane that developed between their fingers was a mixed blessing for these small mammals, for while it enabled them to pursue insects more efficiently, it also drastically increased their body surface area, which in turn, increases heat loss. This factor, along with food availability, has been largely responsible for most bats today being restricted to warm climates. Those that live in the temperate regions of the globe either migrate equatorially during the winter or become torpid.

Mexican free-tailed bats, *Tadarida brasiliensis mexicana*, range throughout the American Southwest and Mexico. Their classification as a subspecies is based on their migratory behavior, that is, populations of these bats migrate between summering and wintering areas in the United States and Mexico. (Free-tailed bats are distributed throughout North, Central, and South America, and some populations, or subspecies, do not migrate.)

The bats of the Eagle Creek colony have short, trim ears, a streamlined body, and long, narrow wings well adapted for fairly long flights. Banding studies have shown that they are capable of traveling at least forty-three miles in one night. The Eagle Creek colony spends the winter somewhere south of the Mexican state of Sinaloa, on the western side of the Sierra Madre. Although the exact location of their winter roost is not known, their seasonal migrations entail minimum flights of 800 miles.

From observations of other colonies of free-tailed bats, researchers have learned that breeding takes place in Mexico during February and March. The bats copulate while hanging from the ceiling of a cave, and the females develop vaginal plugs following mating. The gestation period is from seventy-seven to eighty-four days.

I believe that fertilization triggers northward migration; other researchers think that food availability is the key. But all researchers agree that young bats develop most quickly when the ambient tempera-

Clinging by their toenails, Mexican free-tailed bats roost for the day in the ceiling fissures of a large cave.



ture is roughly 87°F. If the temperature in the cave of a maternal colony rises above this, the young are likely to die from overheating. Free-tailed bats, especially the young, cluster and, therefore, have trouble remaining cool. During the summer, when most caves are simply too hot for the young to survive, maternal colonies of free-tails in Mexico are only found at high elevations (5,000 to 7,000 feet) along the central plateau or in the northernmost states.

At Eagle Creek, free-tails don't winter over because despite the decreased metabolism characteristic of hibernation, energy is still required to maintain the bat. The amount of energy depends on the bat's body temperature during hibernation (which stays about 1.8°F above the ambient temperature). The lower the ambient temperature, the less energy required to maintain the animal through the winter. But the Eagle Creek cave does not get very cold during winter. I doubt whether the temperature ever gets below 60°F at the ceiling of the cave. Thus, hibernating bats would have to maintain a body temperature of at least 61°F over the winter, as they have no physiological mechanisms to lower their temperature below that of the surrounding air. My guess is that this is too high for the bats. Their energy reserves would give out before food became available in the spring. While migration uses up energy, food is available en route to replenish energy losses.

The northward migration occurs from March to June, with the majority of the bats arriving at Eagle Creek in May. In early June the pregnant females give birth to their single offspring or, in many cases, twins. The young have well-developed toenails for clinging to the ceiling, a position they maintain until capable of flight. Those young that lose their grip fall to a sure death. The naked and blind young bats pack together, often apart from the adults. They develop rapidly and are able to fly as early as thirty-eight days after birth.

Throughout the summer nights, the females forage for insects, returning before dawn to indiscriminately nurse the young. No obvious effort is made by the mothers to insure that all the young get fed. The more aggressive young cling to any lactating female that lands nearby and suckle; those that don't, become weak and fall.

As the adults leave the cave in the evening, they rise in a spiraling plume (which flattens out at about 1,000 feet), then disperse into distinct groups, flying at heights of 50 to 100 feet. When they reach





To cool off, some bats fly around the cave, left. On their way to forage, above, they exit in a spiraling plume that rises to about 1,000 feet.

their foraging areas in the Gila River valley, they flutter and dive in quick zigzags after moths and other prey. They scoop up the insects in their tail membrane or wings, then deftly transfer the prey to their mouth. The entire sequence is so fast that it can only be observed with a high-speed motion picture camera.

During the day, the adults sleep on the ceiling, but individuals awake periodically and change positions within a cluster. As they fly to a new sleeping site, their wings circulate the air, cooling themselves and the others in the process. At any moment during the day, as many as 10 percent of the adults may be awake, chattering and moving about. The individuals engaging in this behavior rotate throughout the day—some of the sleepers become coolers, and the coolers go back to sleep.

Little rice-sized pellets of guano, mixed with a fine mist of urine, rain down from the tapestry of bats clinging to the ceiling. The pellets on the cave floor are crawling with the larvae of beetles of the genus *Dermestes,* which make their living by eating flesh, particularly the flesh of dead bats. In spring, when the bats return from their annual migration to Mexico, there are few larvae present on the guano layer. The beetle eggs have lain in the guano during the eight months of fall, winter, and early spring, a period in which little food is available for a carnivorous beetle. Then, triggered perhaps by the urine from the newly arrived bats, the beetle eggs begin to hatch. They mature rapidly, passing through several larval stages before they metamorphose and mate.

In June, the guano pellets lie uncrumbled because there are few beetles, but by August, the guano is covered with writhing larvae and adults. As these scavengers wander the cave searching for carrion they roll the pellets around, eventually pulverizing them. The fragments are worked into a dense mat held together by molted bat hairs and shed exoskeletons from the larvae.

Shortly after the bats leave the cave in late September or early October, the adult beetles lay their eggs and then die. Within a week of the bats' departure, all remaining carcasses on the cave floor have been picked clean. The cycle will be repeated when the bats return the next spring. The history of these annual cycles is visible in cores taken from the guano deposits; each annual layer of whole pellets forms an underpinning for a tough, durable layer of completely fragmented guano. These layers can be separated and dated, and by analyzing them we determined that the bats of Eagle Creek are in trouble. Recent layers were considerably thinner than older ones, verifying a progressive population decline that had been observed by earlier researchers.

In the early 1950s, E. Lendell Cockrum of the University of Arizona estimated the bat population in the Eagle Creek cave at several million. The bat population is now hovering at about 100,000 and decreasing by about 10 percent each year. Similar reductions in the colony of Mexican free-tailed bats at Carlsbad Caverns have also occurred. There is no evidence that the subspecies is increasing its population anywhere over its range.

The primary culprit in the precipitous decline of these bats all over the Southwest may be pesticides. As young bats maturate they



Immature bats grip the ceiling tenaciously, for a fall means certain death. They nurse, indiscriminately, from the nearest lactating female.

build up fat deposits, storing energy in preparation for the fall migration. Pesticide residues accumulate in the stored fat. J. Scott Altenbach at the University of New Mexico has recently determined that pesticide residues in the fat of young bats at Carlsbad Caverns are similar to those found in humans—too low to be toxic. My research group has found that the same low levels exist in the young of the Eagle Creek colony.

Pesticides applied to irrigated crops in the Gila River valley are taken up by the larvae of small moths and other insects. Residues of these toxic substances accumulate and persist through metamorphosis, when the adult insects are eaten by bats. The residues, many of which are fat soluble, concentrate in a bat's fatty tissue and in the fatty fraction of a female's milk. Lactating females actually have a lower body burden of fat-soluble pesticide residues than adult males or nonlactating females in the same population. The residues that the females excrete in their milk is absorbed by the babies and stored in their fat deposits.

During the strenuous fall migration, the young bats burn up their fat deposits. As the fat disappears, the pesticide residues enter the circulatory system and localize in the brain. Levels of such toxic substances in the brain may increase at least a hundredfold during migration. Since these concentrations can be lethal, it is unlikely that many bats affected in this manner survive the long journey to Mexico.

Pesticides may have another deleterious effect on bat populations by removing their food source. The use of poisons in foraging areas could destroy those insects that constitute a major portion of the bats' diet. If staple insects become limited after baby bats are born, their mothers have only two alternatives: abandon their young to seek more abundant food supplies for themselves or remain and starve. My observations of maternal behavior in bats lead me to believe that in such a circumstance the mothers would abandon their young.

At the present time, food availability does not seem to be a limiting factor for the Eagle Creek colony. But the population is only a fraction (3 to 5 percent) of what it was only twenty years ago. The biggest decline in the Eagle Creek bat population occurred before my research began, and may have been tied to insects being reduced in the area by pesticides. Cotton is the principal crop in the Gila River valley, and pests are controlled with aerial application of methylparathion and toxaphene. Over the past twenty years, a variety of fat-soluble pesticides have also been heavily used.

Bat hassling is also taking a toll. One Saturday morning, a caravan of twelve vehicles passed our camp in Eagle Creek and continued down the canyon toward the cave. We heard gunshots, followed by a sprinkling of bats flying back and forth overhead. Twenty minutes later, the caravan resumed its progression down the canyon. Near the cave entrance we found a 20-gauge shotgun cartridge and a .45-caliber shell, and the strong odor of gunpowder was pervasive. From where the shots were fired, no bats could have been hit because the roosting area is out of sight of the entrance. Apparently, these people had simply fired their weapons into the cave to panic the animals into flight. More than an hour after the shots, the bats were still returning to the cave. The animals flew in a loose, circling pattern near the entrance. We climbed the huge pile of guano searching for dead bats, but there were none. Three days later, however, we found a pile of eighty-five dead baby bats being devoured by the dermestid beetles and their larvae. The stress caused by the disturbance of the gunshots may have been enough for the young to lose their grip on the ceiling. They could have fallen for some other reason, but we would not normally expect so many infant bats to die at one time.

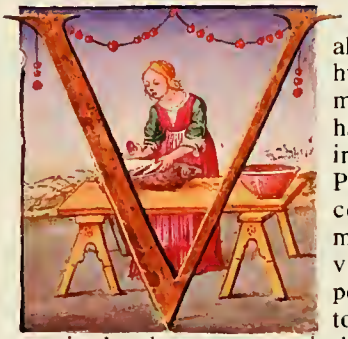
Mexican free-tailed bats need help to survive the twin threats of pesticide stress and human disturbance. Preserving the privacy of maternity colonies and restricting the use of fat-soluble pesticides in their foraging area are the only actions that will save them. □

Ney Cave in Texas has the highest concentration of bats in the United States. Some 25 million Mexican free-tails use the cave at densities of up to 300 per square foot.

The Natural History of Medieval Women

They began to live longer, but they lost economic and social ground

by David Herlihy



ersed in reconstructing all dimensions of past human experience, many modern social historians have become especially interested in women. Partly inspired by the contemporary feminist movement (whose advocates have correctly pointed out that the history of roughly half of humanity has been systematically slighted), these historians also recognize that in the natural and social history of any society, women have unique and critical functions. They carry the new generation to term, sustain children in early life, and usually introduce the young to the society and culture of which they will be a part. Women begin the processes through which human cultures strive to achieve what their individual members cannot—indefinite life, immortality.

Few historians are willing to accept the claims of sociobiologists, who find culture already programmed in genes and who subordinate cultural history to natural history. But most would agree that human societies and civilizations cannot be properly evaluated or appreciated without considering the basic biological experiences of their members. These crucial events—including the duration of life itself under various social and historical conditions, as well as the timing of nursing and weaning, sexual maturity, marriage and mating, reproduction, menopause, and aging—are often by no means parallel experiences for both men and women and can have radically different consequences for each sex.

The biological experiences of women throughout the Middle Ages are interesting because of the length of this particular period: we can observe a thousand years of women's careers and the contours of their lives. Data concerning the Middle Ages are notoriously intractable—difficult to find, difficult to interpret. But medieval scholars advanced some general comments on the biology of women, and a few of these ideas have come down to us; even some precious statistical information that illuminates how women fared in the real world. Finally, some biographies, chiefly of saints and queens, support our rudimentary knowledge of women's situations. All these sources have manifest gaps, but taken together, they present coherent pictures of medieval women. Although medievalists are often obliged to be jugglers and prestidigitators, they are not without pins or beans with which to play.

In the Middle Ages, life expectancies apparently varied sharply, in accordance with epidemiological conditions. For unclear reasons, western Europe was practically free of epidemics from the sixth to the fourteenth century, when the infamous Black Death of 1348–1349 introduced an epoch of recurrent and devastating plagues. From the thirteenth century on, we know the birth and death dates of many medieval nobles and townspeople, predominantly male, and can venture some estimates. In the plague-free years of the thirteenth century, people could expect to live between 35 and 40 years. In the stricken generations including and immediately following the Black Death, life expectancies fell to only 17 or 18 years. It thereafter slowly lengthened and averaged about 30 years during the fifteenth century.

Life expectancies for women shifted up or down in phase with this general movement. But simultaneously, a small, significant change was taking place. Women were beginning to survive better than men; they were acquiring an advantage in longevity that, in the Western world, they have not since relinquished.

Medieval natural philosophers concluded that women's chances for life were improving. The biologists of the ancient world—of whom the foremost was Aristotle—had affirmed that, saving unusual circumstances, males of all species live longer than females (hard work or excessive sexual indulgence might frustrate nature's intent and artificially shorten the male life span). Males represented the perfection of the human species; females were an imperfection of nature, albeit a happy one, in view of their essential contribution to propagation. The defective females passed through all stages of life quicker than the male. They reached sexual maturity sooner, aged earlier, and were the first to die. The ancient biologists thought that specific humors determined a person's temperament and believed that women's temperaments, dominated by cold and dry humors, hurried them toward the cold and dry state of death.

In the twelfth century, when a renaissance of learning began in western Europe, scholars reexamined the biological writings of Aristotle and other classics. Initially, medieval natural scientists repeated without elaboration the ancients' opinion that men, as perfect representations of the species, live longer than women. Then, in the thirteenth century, the foremost biologist of the age, Saint Albertus Magnus (Albert the Great), who died in 1280, treated the question of the relative longevity of the sexes in a novel fashion. In Albertus's view, the Philosopher, Aristotle, was indeed correct. Men live longer than women *naturaliter*, "according

Hunt at the court of Jean le Bon. From a late fourteenth-century manuscript at Versailles.

Editorial Photocolor Archi





Selling chickens. From a manuscript in the Biblioteca Casanatense, Rome.

Scala/EPA



Editorial Photocolor Archives

Fruit and vegetable market, from a late fifteenth-century fresco in Castello d'Issogne, Italy.

to the natural order." But women live longer than men *per accidens,* "by accident," by which Albertus apparently meant under the distinctive conditions of his period. He gives three reasons for women's longer life expectancy: sexual intercourse is less demanding on women than on men; menstruation flushes impurities from women's bodies; and women "work less, and for that reason are not so much consumed." We can question what Albertus meant by the judgment that the demands of sexual intercourse or the purgative functions of menstruation were accidental, but his observation that the burdens of labor lowered men's natural life expectancies is worth remembering.

Subsequently, other medieval authors also concluded that women live longer than men. Some even occasionally pointed out that women must be the superior sex because they live longer and thus fulfill nature's intent better than males. Learned opinion shifted and the ancient belief in the greater life expectancy of males was slowly abandoned.

This change in scholarly attitudes corresponded with an actual improvement in life expectancies for women. From the opening centuries of the Christian Era, we have tens of thousands of funeral inscriptions, from visible standing monuments and from tombstones uncovered by archeologists' excavations. These epigraphs give age at death and allow a rough calculation of the duration of life according to sex. The evidence seems to confirm Aristotle's opinion that at their death, men in these populations of the late ancient era were four to seven years older than women. However, there may be a bias in the data; presumably, the young wife who died prematurely was more likely to earn a memorial than the aged and forgotten widow. But we are certain that women were in short supply in ancient society, either through systematic infanticide of girls or through shorter life expectancies. The biological experience of the women—or baby girls—of classical antiquity was not especially happy.

Unfortunately, we have no comparable epigraphic evidence from medieval populations. The earliest surviving relevant data are sporadic surveys made by the great European monasteries, which wanted clear records of the rents they could expect from their lands. We have between fifteen and twenty of these studies, dating from the ninth century on and enumerating populations settled on particular estates or manors. The largest census was taken by the monastery of Saint Germain-des-Prés in Paris and covers lands that are now mainly Parisian suburbs. Monasterial surveys of the early medieval world characteristically show more men than women, with ratios as high as 130 men per 100 women. Women continued to be in short supply.

Of course, the monasteries may have counted males more carefully. Still, much indirect evidence suggests that women were both few and highly valued in early medieval society. The barbarian legal codes, passed down orally and finally redacted between the fifth and ninth centuries as Christianity spread and introduced literacy, characteristically imposed a fine, usually called a *Wergeld,* on anyone who caused a person's injury or death. The fines protecting women were usually as high as, and sometimes higher than, those protecting men, and women of childbearing age sometimes enjoyed special value. Moreover, in marriage arrangements, the groom brought the dowry to the bride. The male or his family assumed the principal costs of setting up the new household. This reverse dowry suggests that grooms had to compete for relatively few brides.

About 965, an Arab geographer, Ibrahim ibn-Iakub, described Slavic marriage customs, which, in many respects, were typical of all barbarian Europe. Ibrahim reported that the "marital price" required of grooms was so high that "if a man has two or three daughters, they are as riches to him; if, however, boys are born to him, this becomes for him a cause of poverty." Nearly the same complaint would be widely heard again in Europe during the late Middle Ages (1350–1500), but the sexual references would be exactly reversed.



Scala/EPA

Month of February, from the Breviario Grimani, *a manuscript in the Biblioteca Marciana, Venice.*

From the eleventh or twelfth century, the relative number of women in medieval society, and presumably their life expectancies, rose. A rough estimate of life expectancies for the urban and rural population of Pistoia in Italy in 1427 is 29.8 years for women; 28.4 years for men. The shift is most apparent among the high nobility and in the towns. In Bologna in 1395, there were only 95.6 men for every 100 women; in fifteenth-century Nuremberg, there were 83.8 men per 100 women. Even in cities where the sex ratio favored men—as in Florence in 1427—women grew more numerous in the progression up the scale of ages and held an absolute majority among the elderly. Although many older women may have migrated to the city, women probably also survived better under conditions of urban life.

There are several reasons for women's improving chances of survival during the central Middle Ages (1000–1350). The establishment of strong governments and a stable political order lowered the level and reduced the incidence of violence. New ideals of chivalry restricted—although they by no means completely ended—women's active participation in warfare as fighters or as victims. Women fare better under peaceful conditions, when they do not run the constant risk of attack, rape, or abduction. But the most decisive changes were economic. Primitive agricultural economies, with their low production levels, used predominantly the labor of women, children, and the aged. In a famous description written in A.D. 98, the Roman historian Tacitus observed that among the barbarian Germans, women and children maintained the household economy, while adult males gave themselves over to war and indolence. This pattern probably was preserved well into the Middle Ages. But intensive cultivation requires heavy field work, which women cannot readily perform; peasant women in the late Middle Ages worked hard on their farms, but they were no longer alone.

Finally, the new urban economy offered little employment for women. They spun at home, prayed in convents, and labored as household servants, but they did not constitute a significant part of the urban labor force. Families considered their daughters burdens, unable to earn their keep. Girls were also burdens to prospective husbands, and so the terms of marriage turned against women. The reverse dowry all but disappeared, and the girl or her family had to meet the principal costs of marriage. Throughout the late Middle Ages, the social position of women visibly deteriorated, but so also did the social demands and pressures laid upon them. For women, less participation in economic life and diminishing social importance meant better chances of biological survival.

The other principal biological events in women's lives, menarche and menopause, are difficult to examine historically. Medieval medical writers, who abounded from the eleventh century on, commonly placed menarche at between twelve and fifteen years of age and menopause at fifty. But we have no way of knowing whether they were recording their own observations or merely echoing the ancient authorities. Both Roman law and canon law of the medieval Church set the age of puberty and of binding marriage at twelve years for girls and fourteen years for boys. Saint Augustine, who lived from 354 to 430, contracted to marry a girl "two years below the marriageable age"; presumably, she was ten. "I liked her," he reports in his *Confessions*, "and was prepared to wait." He was then thirty years old. Had his conversion to celibacy not intervened, the girl would have been married at age twelve or soon after, to a groom twenty years older. The pattern seems typical of Roman marriages within the privileged orders.

The medieval canonical requirement that girls be at least twelve years old at the consummation of their marriage was a lower bound. There are many indications that girls at menarche were closer to age fifteen than to age twelve. In the law of the seventh-century Visigoths, a girl was not considered capable of bearing children until age fifteen. In a manorial survey of the early ninth century, from the church of Saint Victor of Marseilles, girls are called "marriageable" only from age fifteen. The customs of Anjou in 1246 similarly give age fifteen as the date of presumed maturity for women.

Still, the traditional estimate of age twelve for menarche was not entirely unrealistic. To judge from marriage patterns, which we can discern from the fourteenth and fifteenth centuries on, rich urban girls tended to be very young at first marriage—younger than those of lower social station and younger even than peasant women. Chaucer's wife of Bath, a middle-class, urban woman, was first married at

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Blanche of Castile, upper left, faces her son, France's Louis IX, in the thirteenth-century Bible Moralisée.



Depicted in the Birth of the Virgin, *a fresco by Domenico Ghirlandaio in the Church of Santa Maria Novella, Flore*



in group of five wealthy Florentine women of the same class as Alessandra, wife of Lorenzo Strozzi. Scala/EPA



Scala/EPA

age twelve, and many urban women were already mothers by age fifteen. Social factors were important here: the rich were apparently eager to settle the future of their daughters as early as possible. But the evidence also hints that menarche came sooner among rich women, and amenorrhea (abnormal absence or suppression of the menses) was presumably less common among them. In consequence, rich women in marriage tended to be consistently more prolific than the poor.

Some dietitians argue that girls must achieve a certain critical amount of body fat to trigger menarche and also to sustain menstruation. The better diet and ease of living that rich Roman girls and their medieval counterparts enjoyed gave them low ages of menarche, close to the thirteenth year anticipated in Roman and canon law. Girls in the countryside and among the poor classes were probably at menarche closer to age fifteen—the year most commonly encountered in the barbarian codes, manorial surveys, and customary laws. Perhaps these same groups also experienced relatively early menopause. The laws of the Visigoths assume that a woman would no longer be fertile after age forty. Apart from what we have gleaned from legal sources, we can say little with certainty about these principal events in the female life cycle.

To add flesh and features to our portrait of women, we can rapidly review the lives of three real people—a peasant, a queen, and a bourgeoise. Our peasant is a woman named Alpaix. She was eventually canonized in the late nineteenth century, and even during the Middle Ages, her sanctity was so well recognized that, unlike most peasant women, she attracted a biographer.

Alpaix was born about 1155 in a village near Sens in northern France. Her biographer says that her father, a poor man, "earned his bread by the sweat of his face," by laboriously tilling the soil. Alpaix was the eldest child with several younger brothers. From an early age, she had to assist her father in the heavy work of cultivating the fields. As he drove his two oxen at the head of the plow, she marched alongside, goading the animals to more strenuous effort. When so ordered, she carried manure and sheep dung on her slight shoulders to the fields and gardens. Her young frame could not easily bear the weight, and her father, who seems to have felt no particular sympathy for her, lashed the burdens to her back. Besides her other chores, she had to lead the cattle and sheep to pasture and guard them as they grazed.

All this she did willingly, even on Sundays and festivals, when other peasant girls gave themselves over to dancing and "frivolous things." But then, at the age of twelve, she could no longer sustain the charges laid upon her. According to her biographer, "the tender maiden could no longer bear such heavy labors. Rather, her entire insides were broken and torn from the magnitude of unrelieved work. Drawing deep sighs from the depths of her heart, with the color of her lovely face all marred, she finally gave external, visible signs of her internal suffering. What more can be said? Gripped by unyielding weakness, she remained for an entire year recumbent on her hard and bitter bed, made of straw, without mattress and sheets. . . ." Ugly lesions appeared on her skin, and her body exuded such a repulsive odor that her family isolated her in a hut. For her sustenance, they delivered black bread daily to her door. But because she could no longer contribute to the household, her brothers demanded that no food be wasted upon her. Their heartless proposal implies that the favorable social position of the peasant woman was indeed linked to her labors.

After a year of excruciating pain, Alpaix was visited in a vision by the Virgin Mary, who cured her of her sores and smell. But Alpaix never recovered the use of her limbs and remained bedridden the rest of her life. She took no food apart from Communion, and died in 1211. Before the eyes of this ignorant, invalid peasant girl, spectacular visions paraded; she was allowed to contemplate the splendid court of heaven and terrifying scenes of hell. Her powerful visions gave her a reputation for sanctity, and pilgrims began to find their way to her bedside. Eventually a biographer arrived and preserved for modern historians an account of a girl's hard childhood in the medieval countryside.

Our medieval queen was also acquainted with holiness; she is Blanche of Castile, mother of Louis IX, or Saint Louis, king of France. She was born on March 4, 1188, in Palencia, Spain, the third daughter of King Alphonso VII and the granddaughter, through her mother, of Eleanor of Aquitaine, who had been, in succession, queen of France and of England. Blanche was taken to France, where on May 23, 1200, not long after her twelfth birthday, she married the French heir apparent, who would later reign as Louis VIII (1223–1226). The marriage was not consummated until 1205, when Blanche was sixteen years old. The delay probably indicates, not her own retarded menarche, but the youth of her husband, only a few months older than she.

According to differing sources, Blanche's marriage, which ended when Louis died in 1226, gave her either eleven or twelve children. Blanche's deliveries included one set of twins, born dead in 1215. The spacing of her children suggests that Blanche initially tried to nurse her babies, although the king's disposition and his absences on royal business may also have affected the rhythms of her births. Thus, three and a half years elapsed between the birth of her second baby, Philip (born September 9, 1209), and her next delivery on January 26, 1213, when the dead twins were born. No period of nursing followed here, and her next child, the future Louis IX, was born only fifteen months later. Another lengthy interval of two and a half years followed until the next child, presumably because Louis was being nursed by his mother. Thereafter, births in rapid succession (five or six of them in the eight years from 1219 to 1227) suggest that Blanche—now maturing and occupied with children, household, and the affairs of state—no longer suckled her babies but instead relied on wet nurses. Several tracts on nursing have survived from the thirteenth century, and the assumption in all of them is that the nurse was not likely to be the child's mother.

Blanche's career illustrates the powerful position

Month of October, from a fifteenth-century fresco at Castello del Buonconsiglio, Trento.

that women could still attain among Europe's high nobility in the thirteenth century. Of course, given the shortage of males, many noble girls did not marry. Most of those who remained single were forced into the religious life and all but excluded from lay society. A woman lucky enough to marry, often did so very young, produced babies in rapid succession, did not nurse her own children, and was likely to be relieved of the risks and burdens of childbearing by her husband's early death. Women frequently figured prominently as administrators and regents for their often absent, or short-lived, husbands and sons. At this elevated social level, a widow with children was not likely to remarry; rather, she would dedicate herself to defending and advancing her children's interest.

Blanche herself was effectively regent of France during the minority of her son Louis (1226–1234), and regent again during his absence on the ill-fated Egyptian crusade (1252). She dominated her son and tyrannized her daughter-in-law; she even tried to prevent the royal couple from chatting together before retiring for the night. Surviving her husband by twenty-eight years, Blanche died at the age of sixty-four in November 1254.

The woman who for us perhaps best represents the medieval bourgeoise is Alessandra, daughter of Bardo dei Bardi. She was born in Florence in 1414. We know a good deal about her because a Florentine book dealer named Vespasiano da Bisticci wrote the story of her life. His work, probably the oldest surviving biography of a European woman who was neither a princess nor a saint, tells us, for example, that Alessandra grew to be the tallest young woman in Florence, delighted ambassadors by her grace in promenading and in dancing, learned to read, and could do excellent needlework. She was engaged to be married at age fourteen, but for unknown reasons, the marriage was delayed until 1432, when she was eighteen years old. She was close to the average age of first marriage (17.8 years) for Florentine women in 1427. We can make refined estimates because in that year, a large census was taken of the city. Alessandra's husband, Lorenzo, was the son of Palla di Nofri dei Strozzi, who in 1427 was Florence's richest citizen. Then twenty-seven years old, Lorenzo was young by Florentine standards. The average age of first marriage for males in 1427 was 29.9 years. As Lorenzo was the first-born son in Palla's family, he was probably permitted to marry somewhat earlier. His new wife quickly produced three children in four years—an indication that she was not nursing her own babies.

Disasters then struck Alessandra's family. In 1434, her father, an opponent of the Medici family, was exiled. He was sixty-six years old at the time; Alessandra was twenty. This long generational distance of forty-six years between father and child seems typical of Florentine households. Alessandra's unmarried sisters, left without dowries, were desperate. "What will become of us?" they protested to their departing father. "In whose care will you leave us?" Amid the continu-



The first kiss of Lancelot and Guinevere, from an early fourteenth-century manuscript of Lancelot du Lac.

ing tumult of Florentine politics, Alessandra's husband, Lorenzo, was similarly exiled in 1438, freeing her, at the age of twenty-four, of the risk of further pregnancies. In 1427, the average age of mothers at the birth of their middle children was twenty-six, the fathers' average age was forty.

Lorenzo eked out a living as a tutor in the town of Gubbio, but in 1451 he was assassinated by a disgruntled student. He was forty-six at the time. Alessandra, now widowed, had to raise her children alone. Her biographer presents her as a model of dedication and sober deportment for young widows, of whom there were many in Florentine society. He mentions one other, Caterina degli Alberti, who was married at fifteen, bore two children over the next twenty-three months, lost her husband, and remained a widow for the following sixty years. Alessandra herself remained a widow for seventeen years, and died in 1468, at the age of fifty-four.

The bourgeois woman, like the lady of the landed nobility, was very young at first marriage, and her groom was even older than among the nobles. She, too, bore her babies in rapid succession, did not herself nurse them, and through the death of her older husband, was more likely than the noblewoman to be free of the dangers of continual pregnancies. As a child bride married to a mature man, she probably had little influence on her husband and his generation. But as a young mother destined to have intimate and usually extended contact with her children, she could be a respected and influential figure for the young. Married women occupied a strategic position. As intermediaries between the distant generations of fathers and their children, they could readily shape the tastes and values of the young and thus profoundly influence the culture of the city. And widowhood seems to have suited women well. In Florence in 1427, more than half the adult population of women were widows.

Both the biological and social experiences of women changed substantially during the long medieval centuries. In the overwhelmingly rural world of the early Middle Ages, women enjoyed a high social value and entered marriage under favorable terms. But the bases of their preferment seem to have been the taxing physical labor they performed and the substantial contribution they made to the peasant household. With the growth and transformation of the medieval economy—and in particular the rise of towns from the twelfth century on—women's participation in the domestic economy grew restricted. Daughters no longer made a father rich and the terms under which they entered marriage turned against them. But this partial exemption of women from hard labor conferred some benefits; "they work less," observed Albertus Magnus, "and for that reason are not so much consumed." Women in modern Western history still enjoy some of the advantages and bear some of the penalties bequeathed to them by medieval society. We have yet to see what will happen to these advantages and penalties, in our own, rapidly changing times. □



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Kites of Santiago Sacatepéquez

by Kenneth W. Smith
photographs by Hans Namuth

Held in a cemetery, this Guatemalan festival celebrates the living, not the dead.

In November, strong winds sweep over the mountainside cemetery of Santiago Sacatepéquez, a Maya community in Guatemala. Most days it is a lonely place, empty of all but crosses, tall weeds, and mausoleums. But on All Saints' Day, November 1, the access road from town is jammed with cars as thousands of tourists, together with most of Santiago's residents, gather at the burial ground. At the cemetery entrance, vendors hawk the typical holiday foods—sweet rolls, sliced fruits, peanuts, and juices. Inside this sacred spot, the tourists cluster near the entrance, but the local people break up into family groups to eat, gossip, and eye the strangers—the men remaining on the periphery, drawn together as much by camaraderie as by the presence of *aguardiente*, a 90 proof moonshine made of wheat bran.

Spectators and participants have gathered to witness an annual event unique in Guatemala, and perhaps the world, the flying of some thirty to thirty-five spectacular kites, each of which is ten to twenty feet in diameter. The kites rise in the wind —brilliant kaleidoscopes of colored tissue paper stretched taut over bamboo frames.

To fly a kite with a diameter greater than twelve feet, four to six young men are required. Once a kite is airborne, they strain on the rope, give it slack, and then pull again, hoping for thermals that will lift the kite higher and higher in the air. With steady winds, each team of young men may keep a kite aloft for an hour or two before bringing it back to the ground. If the group succeeds in landing the kite without impaling it on one of the tombstone crosses, snagging it in a tree, or colliding with another kite, it will be flown again and again until a mishap occurs or a tourist offers to buy it, perhaps for as much as $200. But accidents are frequent and by the end of the day, the somber cypress trees surrounding the graveyard are festooned with the shredded remains of unfortunate kites. By nightfall, the wind dies and the crowds disperse—the tourists to their homes or hotels in Guatemala City and the locals to the town where they continue their celebrations. The crowds converge again the following day—All Souls' Day —to see the flying of the remaining kites.

The first day of this worldwide, two-day Catholic celebration commemorates the saints in heaven,



On All Saints' Day, Santiago's living invite their ancestors' spirits into their houses by placing marigolds over doorways and windows.

and the second, the dead in purgatory. As it is practiced in Santiago, however, the ritual has little to do with heaven's saints and is focused almost exclusively on the underworld's dead, the ancestors of Santiago. Many of Santiago's people believe that at sunrise on November 1, God releases the dead from the underworld and allows their spirits to visit the site of their previous life for twenty-four hours. This is a dangerous time for the living, for if the spirits feel they have not been graciously received by their families they may inflict crop failure, illness, accidents, or other woes upon their disrespectful progeny.

Prudent families therefore rise with the sun on November 1, scatter marigold petals around their doorways, and place bouquets of marigolds above every door and window. These are signs to the spirits that they have not been forgotten and that they are welcome to enter the homes of their descendants. Families also place marigolds on the household shrine, along with offerings of liquor, bread, water, fruit, a corn drink, and candles.

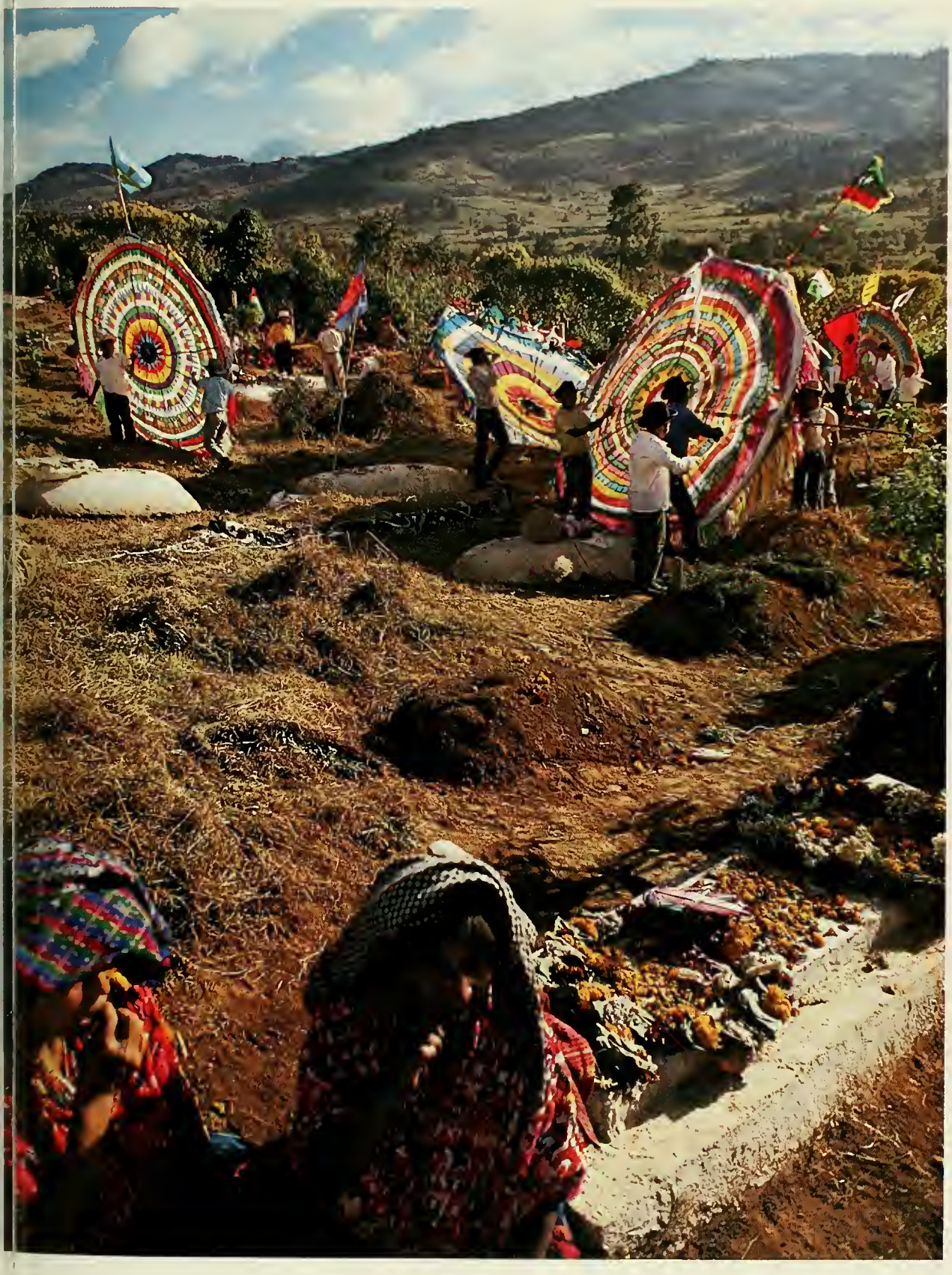
Subsequently, each family makes an early morning visit to the cemetery and adorns the sunbaked earthen mounds of their ancestors' graves with marigolds and cypress wreaths. This visit is always a poignant moment, for Santiago, like much of rural Central America, has an extremely high rate of infant mortality. Testimony to the parasites, gastrointestinal diseases, malnutrition, and other illnesses that kill one-third of the children before they are five years old is provided by the tiny mounds that dot the graveyard. After decorating the resting places of their kin, each family prays. Reminiscing quietly, parents linger at their children's graves. Before returning home, they may set vigil candles and offerings of food near the mounds. In the afternoon, they return again to the cemetery, where by now throngs of tourists have gathered to watch the kite flying.

The association of the sacred days, with their emphasis on death, and the kite flying has led observers to see religious significance in this secular activity. Guatemalan journalists who annually cover the festival assert in their stories and broadcasts that the flying of the kites is an effort to communicate with the dead, to drive malevolent spirits from the cemetery, or to carry messages to heaven. The tourists who come to Santiago are satisfied with this explanation because it fits with their ethnocentric notion that the Maya peasant is superstitious and ignorant. However, during the four years that I lived in Santiago, I never came across this interpretation from the people who actually built and flew the kites. Some of them laughed in response to my questioning and said that they had heard such stories only from tourists.

The flying of small kites on All Saints' Day has been traditional in Santiago, as well as in other Guatemalan and Mexican communities, since before the turn of the century. Before the 1940s, the custom in Santiago was limited to eighteen-inch kites flown by young boys. Use of the larger kites, which are found only in Santiago, originated about thirty-five years ago when three young men built a circular kite four feet in diameter. This kite attracted such attention that the following year, other youths formed teams to construct kites of the same size and larger. By the late 1940s, kites twelve to sixteen feet in diameter were common. To date, the largest kite constructed was twenty-eight feet in diameter, but it proved structurally unsound and collapsed of its own weight.

This elaboration of a traditional custom is not itself to be explained as a historical accident. Kite flying is a prerogative of bachelorhood and may well be connected to the community's courtship customs. This link between kites and courting arises from the Victorian standards imposed on Santiago's women.

While women mourn their dead, the young bachelors of the village prepare to fly their huge, colorful kites.









An unmarried woman must be circumspect in her public behavior if she is not to be the object of salacious gossip. Ordinarily, she leaves her house only to go to market, attend mass, fetch water, wash clothes, and run family errands. Since the participation of women in all other festivals is confined to the church and the home, this festival is the only occasion when large numbers of Santiago women can converse and drink in public for hours at a time. Because the tight reins on customary behavior are relaxed only during these two days, All Saints' Day obviously has special implications for courtship.

Any other time of the year, the only place young men and women can meet and socialize is in the street. These meetings usually take place at dawn before the men go to the fields or at dusk after they have returned. At these times of day, marriageable women invent numerous excuses to run errands, while solitary young men loiter self-consciously on street corners. Each hopes that his favorite woman will come out of her house and provide him with the chance to make a hurried, flowery speech that he has rehearsed in the fields.

Given their limited opportunities to become acquainted with each other, young people have to rely on impressions created by formal speeches, verbal jibes, flashy clothing, and, in the case of males, physical strength. To impress a girlfriend, a suitor will often return from the fields with a huge load on his back and stagger through town in the vicinity of her house.

Thus All Saints' Day is a special time of the year when all the local suitors have the chance to impress Santiago's single women with their unique skills. Their colorful kites serve as whimsical advertisements to women of marriageable age.

Pictures of a Santiago man and woman—and a welcome to tourists—decorate a kite about to be launched by its builders.

Constructing a kite that will evoke public admiration and reflect well on the builders demands time, cooperation, skill, and money. Nearly every kite in Santiago is jointly constructed by a group of four to eight men. Five to seven weeks before All Saints' Day, each group begins construction, which occurs at night after completion of the day's labor. The work sessions are leisurely affairs, the tedious and monotonous cutting and pasting lightened by competitive banter among the builders. The kite's size and colors are determined by consensus.

A few simple materials are used to build the kite—sheets of colored tissue paper, cornstarch for paste, scissors, rope, felt-tipped pens, bamboo poles, and old clothing for the tail. The money expended for these materials, about $30, represents a considerable financial outlay, almost a month's salary, when measured against the earning power of the typical Guatemalan peasant. This is undoubtedly one reason why kites are made by groups rather than by individuals.

An eighteen-inch circle of tissue paper serves as the kite's foundation. From this center, concentric rows of tissue-paper triangles and squares are pasted on each other, each row increasing the kite's diameter. With the fifth or sixth row, the kite is too large to be stretched out flat on the floor of the work space and must be doubled over so work can continue. After the final row is pasted on, the edge is folded back over a rope to create a reinforced border strong enough to hold the bamboo poles that converge, like spokes of a wheel, at the kite's center.

The last steps in the building process include the pasting of streamers along the kite's edge and the addition of graphic symbols on its face. The use of graphics is a very recent innovation. Prior to the 1960s, kites were decorated solely with triangles and squares. Today, most kites carry a motif or design. Perhaps the most common is the figure of a woman, wearing Santiago's traditional blouse and skirt and standing alone or with a Santiago man attired in an army uniform. Sometimes these figures cover three-fourths of the surface of the kite. Other popular symbols make up a highly incongruous list—roses, black widow spiders, rabbits, weapons, rockets, wrestlers, monkeys, scorpions, tigers, and Tecún Umán (a Maya military hero).

If there were any validity to the claim that the kites serve to communicate with the spirits, we would expect to see that theme expressed in the symbols. But such a message is not evident in the motifs of Santiago's kites. Rather, these motifs reflect a preoccupation with heterosexuality, fertility, and masculine power. Sexuality and fertility are embedded in the folklore of the monkey, rabbit, rose, dove, black widow spider, and scorpion. Monkeys are thought to be lascivious and sexually uncontrollable animals and, like rabbits, are reputed to be extremely prolific. Roses are an integral part of the wedding feast. The dove represents love, soul, and the heart. The black widow spider and scorpion are indirectly linked to fertility because the folk antidote for their venom is the ingestion of a pregnant woman's excrement. The depiction on a kite of a Santiago woman and a soldier illustrates the preference the townswomen are said to have for suitors with military experience. Many of the other symbols—eagles, tigers, wrestlers, armaments—represent masculinity.

These elaborate kites are mostly a male courtship stratagem for winning the attention of marriageable women in Santiago's prudish society. As the flying of large, ornate kites is by no means an old custom, the probability that the event has a pronounced religious significance or is an effort to communicate with the dead is not likely. Indeed, a short time ago, kite flying itself was an insignificant part of All Saints' Day celebrations. Now it has virtually taken over the celebrations, attracting spectators from far and wide. Thus, the tissue paper symbolism of the kites is probably more an affirmation of life and procreation than it is a message to the dead. Whether kites have any similar function in our own culture is a rather different question. □

The Shark's Sixth Sense

by Adrianus J. Kalmijn and Kenneth Jon Rose



In addition to the usual complement of sense receptors, sharks have a special sensory capability that humans lack

Three hundred million years ago, long before dinosaurs walked the earth, sharks were present. Today, many other animals are long extinct, but sharks remain abundant and have hardly changed. They are not just remnants of some bygone era but are well adapted to our modern oceans. In part, their adaptation may result from being endowed with an extraordinary sense that is among the most remarkable in the animal kingdom—sharks can find their prey and orient themselves in the open sea by the detection of electric fields.

More than forty years ago, Sven Dijkgraaf, a sensory biologist working at the University of Utrecht in the Netherlands, began to suspect that sharks might have electrical sensitivity. His first clue came in 1934 when he noticed that in experiments with small, blindfolded sharks, they reacted to a rusty steel wire. When the wire was brought within approximately one foot of a shark's head, the fish would suddenly turn away. To establish whether sharks would react in a similar manner to a nonmetallic object, Dijkgraaf repeated the procedure with a glass rod. The sharks ignored it until the rod actually touched their skin. Only then did they move rapidly away.

The sharks' reactions seemed to duplicate the experimental results Dijkgraaf had read about in a paper published in 1917 by two Harvard University scientists specializing in the sense organs of fish. Working with the common brown bullhead, a species of freshwater catfish, the Harvard researchers had tested the response of blindfolded fish to metallic and nonmetallic objects. The catfish reacted then as Dijkgraaf's sharks did seventeen years later, responding to the metallic rod when it came within a range of one to two inches and to the nonmetallic rod only on contact. In subsequent experiments, the two scientists showed that the reactions of the catfish were not due to movements of the hand-held metallic rods or to odor particles emanating from them, but were the result of electrical currents given off by the metal objects upon contact with water. Because of the similarity of his results to the Harvard studies, Dijkgraaf assumed that his small sharks were responding to the electric fields produced in the water by the rusty wire.

In 1951, long after these early observations, a British sensory biologist named Lissmann studied those species of tropical fish of the Amazon and the Nile that have special organs that generate electric fields in their environments. He was less concerned with animals, such as electric eels and electric rays, that produce strong electrical discharges in order to stun their prey, than with species that create much weaker fields that are too feeble to be harmful either to their natural prey or to other animals.

Lissmann found that many South American knifefish and weakly electric fish from the African continent emit pulsed discharges continuously throughout their lives. To explain the function of these fields,



New York Zoological Society

he suggested that these fish probe their environs electrically. That is, they monitor their own fields and are able to detect nearby objects through the distortions those objects cause in the electric fields the fish themselves generate. Lissmann proposed that weakly electric fish such as the knifefish evolved from what he called a preelectric fish, meaning a primitive one lacking electricity-generating organs but possessing receptors sensitive to electric fields. Today, the concept of a hypothetical preelectric fish is quite believable, for we know that catfish and sharks are acutely sensitive to weak electric fields but lack the organs to create their own electrical milieu.

Just how sensitive sharks are to weak electric fields has been demonstrated experimentally by Kalmijn. He found that within the frequency range of direct current up to about 8 hertz, sharks respond to fields of voltage gradients as low as a hundred-millionth of a volt per centimeter. That would be equivalent to the field of a flashlight battery connected to electrodes spaced a thousand miles apart in the ocean. Little wonder that this sensitivity is the highest known in the animal kingdom.

Sharks owe their astounding sensitivity to electric fields to several hundred sensory organs in the head region called the ampullae of Lorenzini. These organs are marked by pores in the skin of the animal's snout, leading to jelly-filled ducts that terminate in sensory cells. Scientists have known about the ampullae of Lorenzini for years, but their function had long been a mystery. Early researchers believed the organs to be sensitive to pressure, perhaps informing the shark about water depth. But that hypothesis appeared to be fallacious and was soon rejected. Later, the ampullae were found to be temperature sensitive, but this did not seem to be their function either. Finally in 1963, Dijkgraaf and Kalmijn, who were then working together, established that sharks use the ampullae of Lorenzini to detect weak electric fields. This discovery solved the mystery.

Once the function of the ampullae had been correctly identified, a basic question still remained: How do sharks make use of their electroreceptive capability?

Virtually every living creature unintentionally produces in water an electrical field so weak it can only be detected by the most sensitive instruments. This results from differences in the electrical potential of the skin, which varies from one bodily area to another. Because water is an electric conductor, these differences produce electrical currents. For example, in the fish that sharks take as prey, the mucous membranes lining the mouth and the gill epithelia in the pharynx create direct-current fields that fluctuate with breathing movements. These currents flow through the water along field lines around the animal and, in accordance with the laws of physics, become rapidly weaker and weaker with increasing distance from the animal. Even so, the voltage gradients emanating from small fish and wounded crabs, the main diet of many sharks, produce, within a distance of about one foot, bioelectric fields well within the shark's sensory capabilities.

These findings suggested that sharks may use their electrical sensitivity to locate their prey. In 1971, Kalmijn began laboratory experiments designed to test that hypothesis. He put a small, live flounder in a sandy-bottomed tank containing hungry sharks of the species *Scyliorhinus canicula*. Flounder and other small fish are part of the normal diet of these sharks. The flounder swam to the bottom of the tank and buried itself in the sand. Then Kalmijn added a few drops of odoriferous liquefied fish extract to the water to arouse the sharks. (Sharks will go without food for days until they are motivated and attracted by its smell.) Excited by the odor of the extract, the sharks began frantically searching for food. When they came close to the buried flounder, they made well-aimed dives at it, uncovered it from beneath the sand, and devoured it voraciously. Since the flounder was hidden and the fish extract was diffused throughout the tank, it would appear that the sharks must have used cues other than visual and olfactory ones to find their prey. Might the sharks have located the flounder by intercepting its electric field?

Sharks not only have a keen sense of smell but, like most aquatic animals, they are also sensitive to minute movements in the water. They perceive these movements with microscopically small organs in the skin along a visible band, called the lateral line, that runs the length of the body. It was possible, then, that the sharks might have sensed the hidden flounder either by its odor or its movements. The next step was to make sure that the sharks had not sensed the hidden flounder merely by these means.

An enclosure consisting of agar, a stiff, opaque, gelatinous substance, was put around the flounder. Agar is a pretty good barrier to odors and water movements but permits the transmission of electrical fields. Under these experimental conditions the sharks continued to make well-aimed attacks at the buried flounder from the same distance and in the same frenzied manner as if the prey were not shielded by the agar. To make sure that the thick agar roof of the enclosure was really effective in stopping any possible odor from leaking out, the live flounder was exchanged for cut pieces of fish, which produce an even stronger odor but do not generate electric fields. If odor were to come through, the sharks would find the bait within minutes. Instead they swam over the agar chamber without showing the slightest interest in the food. Obviously the agar was odorproof.

To establish beyond a doubt that the electric sense was the means by which the sharks had located the live flounder, the agar enclosure was covered with a plastic wrap. This served as an insulator that would contain any electrical field within the enclosure but would not impede any water movements and vibrations that might have passed through the agar. Under these conditions, not a single shark noticed the live flounder. Electricity clearly seemed to be the medium the sharks were using to find their prey.

Seth Rose



The feeding behavior of dogfish sharks was observed in the waters off Cape Cod. This specimen, like others, was first attracted by the odor of fish extract released through an opening in a plastic tube marked by white tape. The sharks then zeroed in on a set of live electrodes marked by red tape.

As a final proof Kalmijn simulated the presence of the flounder in the tank by passing a weak electrical current between two electrodes buried in the sand. The effect was dramatic. Motivated by a few drops of fish extract spread in the tank, the sharks charged at the electrodes as if they were the real prey. They dug away the sand and bit them. Responding again and again when swimming over the electrodes in their search for food, the sharks left the site only after finding it really contained none. So tempting was the artificially generated electric field, that when a piece of odor-producing fish was placed a short distance from the electrodes, the sharks, although attracted by the odor, continued to dive at the electrodes rather than at the fish.

The aforementioned electrical tests were all conducted in the laboratory where the scientist can control the environment. However, captive sharks in a tank might react differently from sharks in their natural habitat, where many stimuli affect them. The authors, Kalmijn and Rose, therefore decided to verify the laboratory data by testing wild specimens roaming freely in the ocean, even though that would present many problems.

Human beings swimming in the sea produce their own electric fields, which sharks can detect from distances of up to about three feet. The fields produced by metals carried or worn on the body, scuba gear, for example, are usually even stronger. Thus, when studying sharks in their natural environment, we would have to get close enough to work with them without introducing electric fields from our bodies or from metallic equipment we might use in the water.

During the summer of 1976, while fishing off Cape Cod, Massachusetts, we learned that the smooth dogfish shark, *Mustelus canis*, regularly frequents the shallow, inshore waters of Vineyard Sound on its nightly feeding excursions. This predatory shark is a warm-season visitor from equatorial waters, which arrives north in May and returns south in late October or shortly thereafter. It is an active bottom hunter, preying on small local fish as well as on crustaceans and other invertebrates. The females reach an average length of slightly over three feet, the males are somewhat smaller. We decided to use this shark for a series of nocturnal studies.

To observe the animals' feeding behavior, we had designed a nonmetallic field setup that would reproduce our laboratory tests in a natural setting. Using a triangular pulley system, we ran a length

of rope and plastic tubing from a rubber raft to a bare patch of sand seven feet below us and back to the raft. In the center of this system was an opening in the plastic tube through which we could release fish extract as an odor source. One foot to each side of that opening were two sets of electrodes that would simulate a flounder's electrical field.

After dispersing several chunks of herring (a readily available substitute for flounder) over the area, we began to pump small amounts of liquefied fish through the tubing to attract the sharks. At the same time, we turned on one set of electrodes, leaving the other off as a control. The otherwise dark area was illuminated with an insulated underwater light and we made our observations through a glass-bottomed viewing box. The glow in the water extended for some twenty feet around the raft but, surprisingly enough, seemed neither to attract nor scare the sharks.

The first animal to appear on the scene was an American eel attracted by the odor of the herring extract. It wandered in and nibbled at the odor source, ignoring the electrodes. Soon a much larger animal swam into the cone of light. It was *Mustelus canis*. Within minutes, another shark appeared. Together they circled the illuminated area, apparently trying to locate the odor-releasing, presumed prey.

Gradually the sharks began to zero in on the odor source but before reaching it, they suddenly turned sharply toward the current-passing electrodes, biting and thrashing at that portion of the rope. The hole from which the fish extract was emanating and the control, or "dead," electrodes were ignored. During several nights of research, hundreds of sharks were observed, and all of them responded in this way.

These observations clearly demonstrate that sharks, roaming freely in their natural habitat, can detect and take their prey by the exclusive use of their electric sense. The



experiments also show that within the range of one foot, electrical fields override the vague odor cues that initially arouse and attract sharks from a distance of many yards. The odor of a wounded prey lingers in the water long after the prey has gone. Therefore, when following an odor trail, sharks ultimately depend on a more localized and precise cue to spot their prey accurately and to seize it with one quick move.

In addition to using its electric sense to find its prey, it is possible that sharks rely on this sense for other purposes as well. As already noted, the smooth dogfish sharks we observed in the waters off Cape Cod migrate southward during the winter. They must therefore be endowed with a good sense of direction. Kalmijn believes that this sense may be electrical and may derive from the animals' ampullae of Lorenzini.

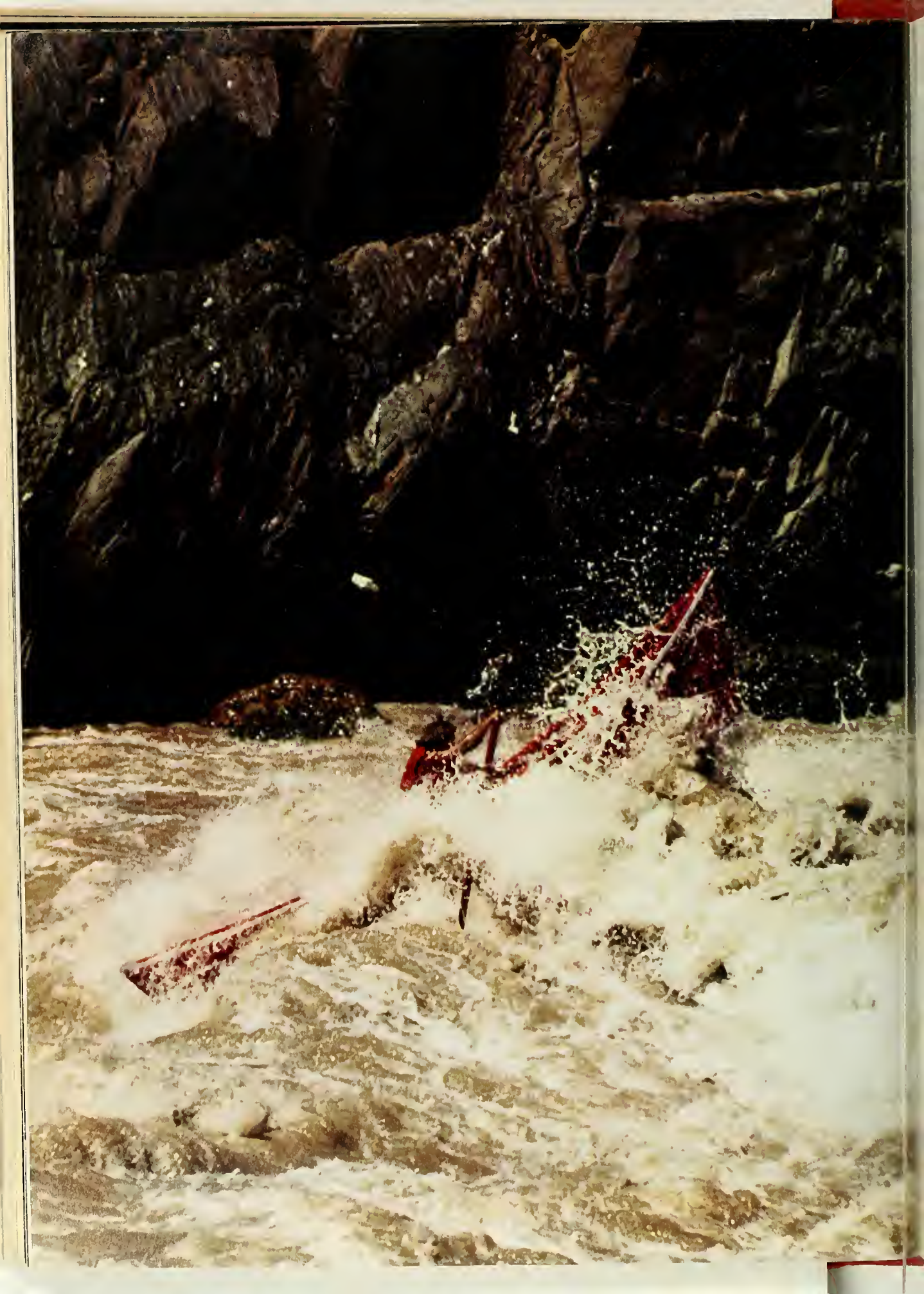
When a fish swims through the earth's magnetic field, an electrical field is induced. The polarity of these induction fields depends on the direction in which the animal is moving. Reception of these fields through the ampullae of Lorenzini may thus indicate to the animals the compass direction they are following. Sharks, in a manner of speaking, may have an internal electromagnetic compass.

The shark's ability to orient with respect to the earth's magnetic field has already been demonstrated in laboratory experiments. To verify these new findings and extend our earlier observations, we are currently outfitting a mobile, nonmetallic working platform (a modified Boston Whaler) for comparative studies of the electric sense not only of shallow-water, bottom-dwelling sharks but also of the open ocean, pelagic species of the Cape Cod area.

Although sharks have recently received a spate of bad publicity, most species are, in fact, harmless to humans. It is our contention that the shark should be respected, if not admired, as an ancient survivor possessing a special sense not acquired by most animals. □



Tom McHugh, Photo Researchers



Who Runs the Grand Canyon?

by Fred B. Eiseman, Jr.

The National Park Service has given commercial operators a near monopoly on boating the Colorado River

When Congress established Yellowstone National Park in 1872, would-be visitors had a problem. The country's first national park was so difficult to reach that only the rich and the ultra-adventuresome could get to the fabled geysers, let alone stay there and absorb the scenery. Yosemite presented a similar problem. President Lincoln signed over Yosemite to the state of California in 1864, and it became a national park in 1890. It, too, was virtually inaccessible, and only a few hardy individuals could enjoy the scenes vividly described by John Muir.

Congress set aside these areas of natural beauty for the public so that, as Senator Trumbull of Illinois put it, no member of the land-grabbing fraternity could "plant himself right across the only path that leads to these wonders and charge every man that passes along between the gorges of these mountains a fee of a dollar or five dollars." Guided by the sad example of Europe's natural wonders, purchased by the rich for use as their personal playgrounds, Congress wanted to insure that the public could visit and enjoy these areas and, at the same time, preserve them for future generations.

But how could the common man enjoy areas that he could not get to? The solution was to allow private industry to provide means of access to the new parks and accommodations for visitors in and around them. In 1916 when an act of Congress created the National Park Service, its first director, Stephen Mather, encouraged tourist-oriented companies (or concessioners as they came to be called by the park service) to provide transportation and lodging for park visitors.

Operating with little competition, concessioners built restaurants, cabins, trails, souvenir shops, hotels, and all the other conveniences that tourists were willing to pay for. The Santa Fe Railroad at Grand Canyon; the Union Pacific at Zion, Bryce, and the North Rim of the Grand Canyon; and the Great Northern in Glacier were among the early concessioners, and their successful enterprises earned handsome profits. Spelled out in numbers of visitors over the years, the national parks were an enormous success.

In 1965 Congress passed the Concessions Act, which made official the previously informal agreements between the National Park Service and the concessioners. This legislation recognized the existence of concessioners and stated that their operations were proper if their services were appropriate and necessary. The rest of the act concerned itself with such matters as franchise fees, possessory interest in concessioner-financed facilities on national park land, contract details, and other technical matters. The assumption seemed to be that concessioners were doing a great job and that their presence was an asset; indeed, the sine qua non for the success of the national parks.

But things have changed in the past decade. On the cover of the first issue of a newsletter put out by river-running enthusiasts in the Denver area is a picture of the Grand Canyon captioned, "For Sale: Contact the National Park Service." The National Park Service (NPS) has been taken to court three times in the last two years over the matter of its concessioner policy. Environmentalists and wilderness enthusiasts are up in arms; angry letters go regularly to congressmen. What has happened?

Two things. First, along with their financial success, concessioners have acquired political power. Many of them have millions of dollars invested in their national park operations and are naturally concerned that their profitable operations continue. Some of the biggest concessions have been bought up by large conglomerates. For example, Amfac, a Hawaii-based giant, now owns the South Rim Grand Canyon concession; Music Corporation of America (MCA) operates the facilities at Yosemite; and TWA

Maneuvering through the white water on a stretch of the Colorado River as it rushes down the Grand Canyon, a boatman struggles with the lead boat of a party of private river runners. Such enthusiasts have great trouble making the trip because commercial tour operators have been allocated the lion's share of the permits.

photographs by Margaret Eiseman

runs the show at the North Rim of the Grand Canyon. Along with size and money goes political clout. And along with political clout goes influence in the operations of the National Park Service.

Congressional hearings were held in 1974 and 1975 to determine whether MCA's influence on the operational policies of Yosemite National Park had benefited MCA rather than Yosemite. Among other things, the NPS was criticized for allowing concessioners to provide visitor services that were surely not necessary and hardly appropriate, to use the language of the Concessions Act. For example, one Congressman wondered why MCA maintained a Pitch 'N' Putt golf course in Yosemite; whether MCA's thirteen liquor-selling stores within the park contributed to the enjoyment of the natural scene; whether the filming in Yosemite of a television series by Universal Studios (a subsidiary of MCA) was in the interests of the park; whether the park service's permission for Universal to paint some of Yosemite's cliffs was in accord with the mandate that the park service should conserve the scenery for the enjoyment of future generations; whether it was good policy to book conventions in Yosemite's hotels, thereby making hotel rooms unavailable for other tourists; and whether holding a Winter Wine Festival in Yosemite was an appropriate national park activity.

The point is well stated in *National Parks for the Future,* issued by the Conservation Foundation in 1972:

> There was a time when concessioners were clearly needed to provide basic services for accommodations, food, and the like. Without them, the parks could not have become a reality to so many citizens. Today, however, the concessioner has a disproportionate influence on planning and policy making for the national parks. His objective is to generate as much demand for the services he provides as is possible. This is thoroughly understandable but it too often brings the people to the parks for the wrong reason. The predictable result is that the concessioner makes a case for further facilities to accommodate a market that he—not the parks—has created. In some cases these new facilities are utterly inappropriate.

So this is one factor in the new protest movement—the power and political clout of the concessioners. The second is the enormous boom in outdoor recreation. In the old days many of the national parks were difficult to reach, visitors had no place to stay when they arrived, and nothing to eat except what they brought. Hence the need for con-



Only group leaders and boat handlers need experience in running the river, whether the trip is private or commercial. The passengers need merely hang on and enjoy.

cessioners. But today paved highways lead at least to the edges of all national parks. Comfortable backpacks, air mattresses, and hiking boots are within the financial grasp of millions of outdoor enthusiasts, and the desire to use them increases yearly. Light, tasty, easily prepared dehydrated foods are available at any sporting goods store, and it is simple for a backpacker to carry a week's supply of food, together with a tent, sleeping equipment, and lightweight clothing.

In other words, there has been a huge increase in the ability of the general public to reach hitherto inaccessible public lands and in the desire of people to enjoy these areas without the services of professional guides.

As a result, many public lands are becoming overused, and environmental degradation is on the increase. Thus, the NPS and other administrators of public lands have imposed limitations to protect these areas. These restrictions have also reduced the distractions that result from too many people in one place at one time. Let us call these areas "rationed," that is, permits from the managing agency are required in order to visit the area in question. The inevitable result has been competition for permits to rationed lands between concessioners and the outdoor enthusiasts who want to go there on their own, and to whom the whole idea of a "group tour" in a wilderness area is repugnant.

This is something that neither Congress nor such seminal thinkers as Muir and Olmsted, whose enthusiasm led to the national park concept, ever contemplated. There is no legislation to guide the NPS in how to handle this competition. Apparently, nobody foresaw the enormous success of the idea of protecting wilderness lands or the desire and ability of millions to visit them.

An important example of this conflict is the situation relating to white-water boating down the Colorado River in Grand Canyon National Park. Alarmed by environmental damage along the canyon shores of the river, the National Park Service set a limit on use. Having no data on which to base an intelligent carrying-capacity limit, it was decided, pending further studies, to simply hold the line at the actual use of the river in 1972.



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In recreation circles, use is often measured in terms of user-days, one user-day being one person in the area for one day. For example, if three people are in an area for six days, eighteen user-days are attributed to them.

The competition for user-days is between the twenty-one concessioners who have been granted NPS permits to run river trips and a large number of private, noncommercial river runners who prefer to organize their own expeditions. The interests of the two groups differ considerably.

Customers of concessioners need not apply for permits. All they must do is pay; necessities and services are provided by the concessioner. Such trips resemble the package tours offered by travel agencies, with fixed itineraries and rigid procedures. Most concessioners use inflatable rafts powered by outboard motors.

The park service requires private river trips to be participatory; responsibilities and activities must be shared and no individual is allowed to profit from the venture or write off the cost of the equipment. Passengers are charged only for their food and for transportation to and from the river—an expenditure far less than the commercial rate. Surveys indicate that private river runners are generally younger and less affluent than commercial passengers. Noncommercial trips have fewer people, last longer, are less structured, allow more time for visiting canyon attractions, and use oars in place of outboard motors.

In 1972 the twenty-one concessioners who held river-running permits consumed 89,000 user-days, and the private river runners had 7,600 user-days—breaking down to 92 percent for concessioners and 8 percent for private parties. In the years since then, there has been an ever increasing demand for private permits. The 7,600 user-days allotted to private river runners has proved utterly inadequate. As a result, the NPS has set up a yearly lottery for the private river runners. Applications for permits must be received at National Park Service headquarters several months before the river-running season begins. Applicants must be the leaders of the groups (of no more than fifteen people) that wish to make the trip. They must satisfy the NPS that they have had adequate experience, that their equipment is safe, and that they understand the various regulations imposed on canyon travel. (Because it is considered unsafe for a person to make the trip alone, applications for individual use are rejected.) On the appointed day of the lottery, the names of qualified group leaders are drawn at random until the 7,600 user-day limitation is reached. In 1977, there were 515 applications for private permits by qualified group leaders. Thirty-seven were chosen, filling the 7,600 user-day allocation.

If each of the 515 applicants represents a group of twelve people, then 6,180 people wanted to run the river. Since an average private trip might last about two weeks, this demand would represent about 86,520 user-days—nearly the entire commercial allotment of 89,000, and more than eleven times the 7,600 user-day allotment for private parties.

The private river runners are outraged. Many have the experience and expertise, and all have the strong desire to make this "sock-dolager" of all white-water trips; yet in order to go, they would have to hire the services of a concessioner to do for them what they are perfectly capable of doing for themselves. Many concessioners do not fill up their trips during the season. Last spring, one disappointed applicant for a private trip decided to apply for space on a commercial trip. He was able to secure space on five of the first six trips that he inquired about.

River-running enthusiasts point out that these are public lands, originally reserved by the government for the use, without cost, of the general public. They ask, How does the present situation differ from the situation that Congress sought to avoid when parks were originally established? A strict reading of the Concessions Act indicates that concessioner services are hardly necessary today because enough people want to run the river on their own as there are user-days allowed by the National Park Service. Environmentalists fear this is just the first example of what could become a trend. Perhaps some day private canoeing, private burro packing, private scuba diving, or private trail hiking in the national

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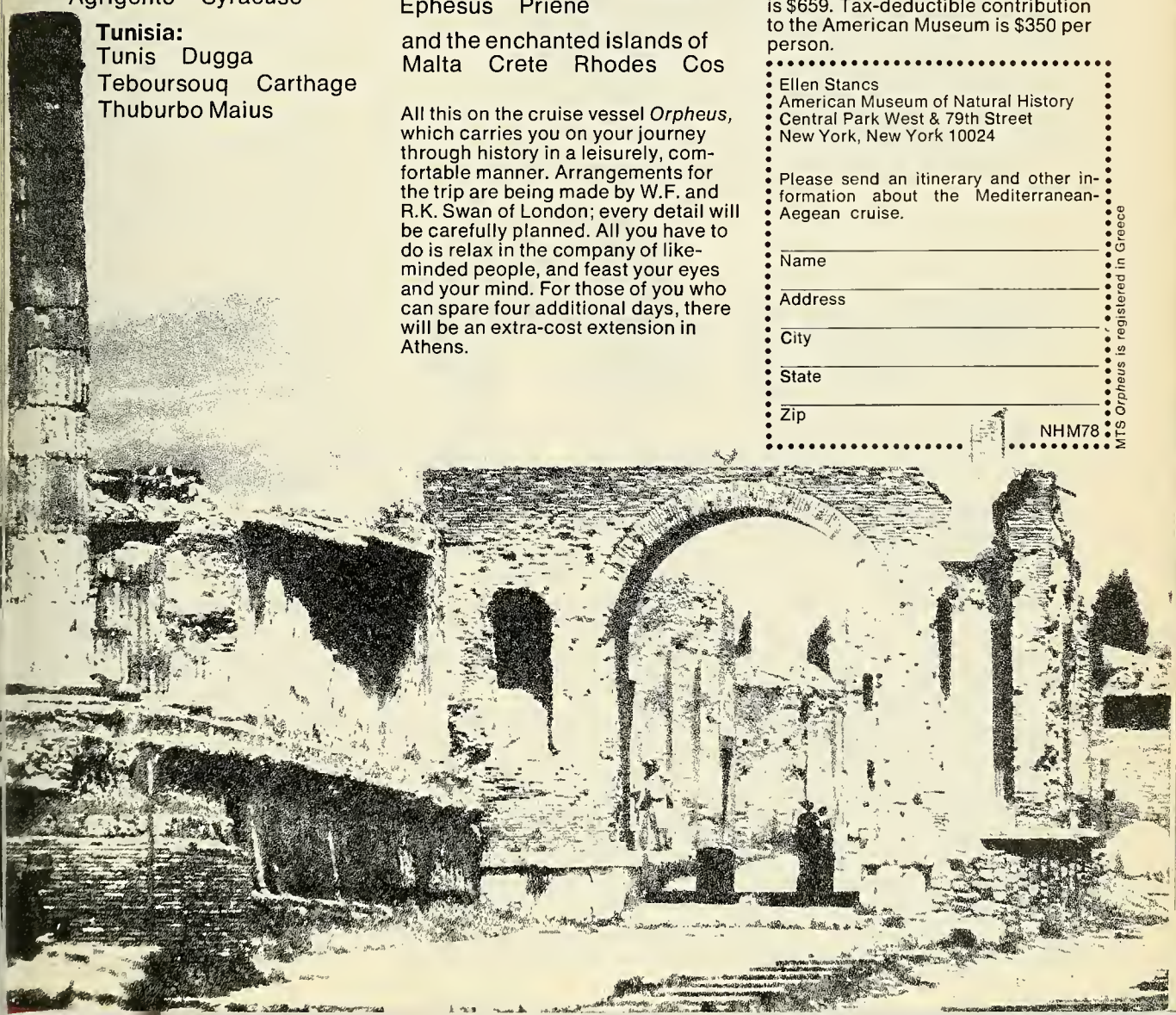
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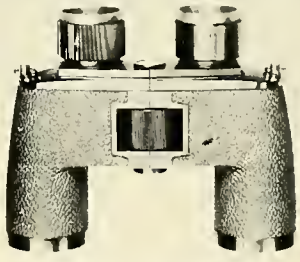
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parks and other government-controlled lands will be effectively prohibited and the noncommercial outdoorsman will be required either to hire a guide or go on a group tour.

Meanwhile, the twenty-one concessioners enjoy a $4.5 million industry, with the apparent blessing of the NPS. River running in Grand Canyon has become an "in" activity. Lindblad has offered tours complete with ice cream and shrimp. *Playboy* has sent its bunnies down the river to be photographed *au naturel*. Meanwhile, private river runners keep their feet dry and sizzle with rage.

The National Park Service justifies its position on the grounds of lack of information. Since 1972 the agency has had an expensive research program to explore the river environment that it is supposed to be controlling. It states, justifiably, that it can scarcely impose a realistic carrying capacity on river use without scientific knowledge of the effects of human use. NPS even sponsored a study of river runners to determine demographic differences between those who go on motorized trips and those who prefer rowing trips; attitudes toward crowding, group contact and interaction; and the characteristics of commercial and private users. The park service says that it cannot make a meaningful allocation between commercial and private users until the results of such research have been analyzed. Private users retort that the river research has not addressed the conflict of private versus commercial use, other than the brief and fragmentary study of demographic and attitudinal differences between the two groups.

The concessioners claim that the private river runners are elitists who do not represent the general public. They claim that their customers are really the public—bricklayers, taxi drivers, doctors, and little old ladies who have neither the desire nor expertise to undertake the hazardous trip on their own. Concessioners claim credit for the popularity of the river run because their regular, safe, scheduled trips fit neatly into a vacation package, including pickup upon arrival at the airport and delivery to either Las Vegas or the airport at the end of the trip.

Private boaters talk about the

repugnance of offering nature at a price and of reducing one of the few remaining pristine white-water areas to the status of a Disneyland ride. Environmentalists point out the values that accrue to people who must plan their own trips, read their own maps, be self-reliant, and, in short, cope with nature on its own terms, rather than just present a credit card to the local travel agent and then be entertained for the duration.

A commercial passenger pays between fifty and sixty dollars for every day spent on the river. Now, admittedly, this is a bargain. Where in the United States could one get a room (in this case a sleeping bag), three meals a day, transportation, and a guide for that price? But it is still cheaper to go privately. If one has the boats and other equipment, as most river runners do, the cost of a do-it-yourself river trip would be about one-tenth that of a commercial trip. Private boaters also point out that a good many of the commercial river trips are whirlwind, "gee whiz" runs of four or five days in which about 250 miles of canyon are negotiated. They claim that concessioners make the most money when they push the maximum number of bodies down the river in as short a time as possible.

The National Park Service has been in a bind since 1972. If the agency were to increase the private allotment of user-days, the concessioners would scream and bring pressure to bear in Washington. This happened six years ago, when the NPS, after holding public meetings, issued a plan whereby the total allotment for river use would be drastically reduced over a period of several years and motors would be eliminated in a four-year phase-out. Concessioners appealed to their friends in Congress and the plan was blocked.

On the other hand, if the NPS increases the commercial allotment, as the concessioners demand, the private sector would object even more loudly than they do now. The result, predictably, is that the NPS has done nothing; figuring, apparently, if they do nothing, they can do no wrong. This situation has continued for six years.

In January, however, the long-awaited draft of a Colorado River Management Plan and an environ-

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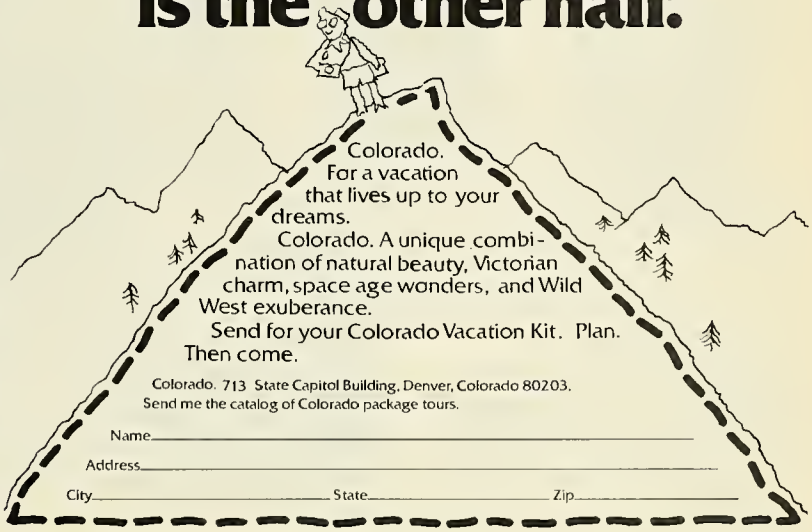
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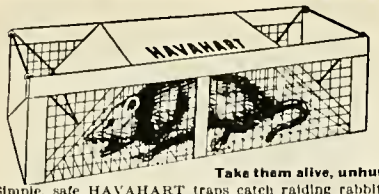


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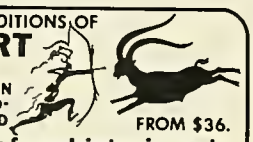
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mental impact statement were released by the National Park Service. The plan only contains proposals, subject to changes after public hearings and comments. Indications are that a minimum of two years is needed before the plan in final form can be implemented.

The new proposals attempt to resolve the conflict over who runs the river by increasing the total number of user-days by 100 percent, changing the ratio from 92:8 to 70:30, and eliminating motorized trips by 1981.

The National Park Service requires that private river trips be participatory. All group members are supposed to share the expenses, activities, and tasks of an excursion.

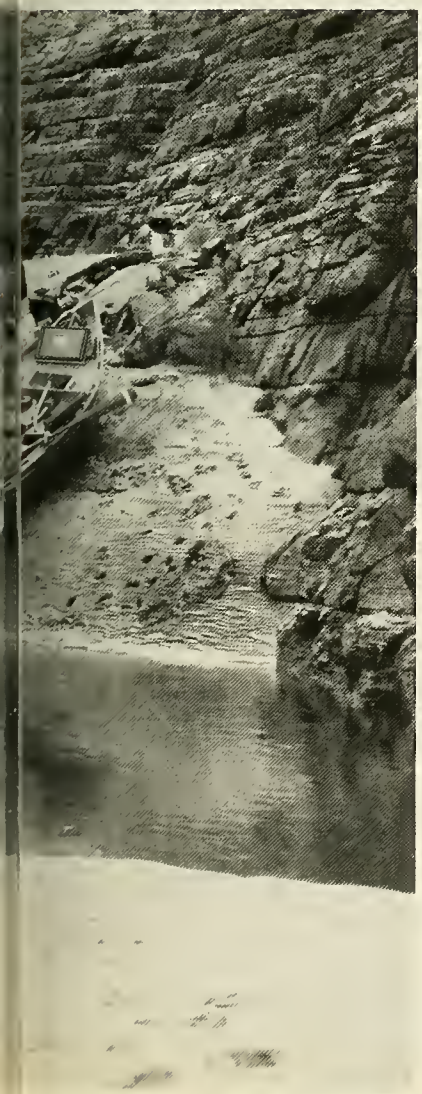
In its attempt to please everyone, the agency will please no one. Private users will continue to object to any arbitrary allocation; concessioners will object to the phase-out of motor use and a smaller percentage of the total number of user-days; environmentalists will be appalled by the doubling of visitor use. Fur will fly, and the plan will probably meet the same fate as the 1972 proposals when political pressures are again applied.

So, having exhausted their patience, and with virtually no support on the part of Congress, the private boatmen have taken various steps. The first of these was the organization in 1975 of the Wilderness Public Rights Fund by a group of outdoorsmen. WPRF petitioned the Department of the Interior to rectify the situation. Having failed in this quest, it filed suit against the National Park Service in Federal



District Court in San Francisco. The essence of this suit was that existing laws indicated that private recreationists have priority of right to use public lands, and that they should be given preference to permits in areas where use is rationed. The case was decided against WPRF, and they have appealed.

A second lawsuit was filed by four river runners in Arizona. Their thesis was that *any* allocation between private and commercial permits is illegal because it exceeds the authority of the Secretary of the Interior under the Organic Act that established the National Park Service in 1916. The suit further alleges that the decision of the NPS to limit use of the river to the 1972 level violated the Administrative Procedures Act because it was not subjected to public hearings and was not published in the Federal Register. And, finally, the plaintiffs



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stated that the ratio of use between private and commercial permits violates the Fifth Amendment of the Constitution, which prohibits classification of citizens and different treatment of the several classes, as, for example, those who, by reason of wealth, can afford to hire a guide and those who cannot. This case was judged against the plaintiffs and is now being appealed.

The third suit was filed by the Sierra Club in September 1977. The basis of this suit is slightly different from the other two, which were based on legal, nonenvironmental grounds. The Club, on behalf of Grand Canyon National Park, is suing the NPS because the latter renewed the permits of all of the concessioners when they expired at the end of 1976, even though the service's own research indicated that environmental damage was being done by people running the river. The suit states that the requirement of the Organic Act is that the park service protect its lands undamaged for the enjoyment of future generations. No action has yet occurred on this lawsuit.

So the situation stands. The National Park Service has interpreted its two legal victories as a broad mandate to allocate land use between the private and commercial sectors. The plaintiffs hope that more scholarly thinking by Courts of Appeal will reverse lower court decisions and interpret the law according to their point of view. Private river runners have planned civil disobedience protest trips, but these have not come about because none of the media thought the cause interesting enough to cover. River-running groups, such as the one whose newsletter sarcastically offers the Grand Canyon for sale, urge their members to write to their congressmen. But few influential congressmen pay any heed to the relatively unorganized ranks of the private boaters. The concessioners are organized. Their passenger lists can produce thousands of identical messages to senators and representatives, singing the praises of the commercial services. The private boaters are a proud and independent lot who really don't care much for organizations, dues, and legislation.

Meanwhile, the NPS goes its way, sniffing the bureaucratic winds and bending in the direction of the most powerful ones. Private recreationists fear for their future right to enjoy public lands on terms compatible with their own souls, and concessioners plump for further rights and privileges.

The four Arizona plaintiffs, and others, have urged the adoption of a plan that would provide each person desiring a river-running permit an equal opportunity of receiving one. Under this plan everyone, be he or she a private or commercial passenger, would apply for a permit. These would be allocated by lottery up to the limit imposed on the river's use. And the winners would then be free to go by whatever means they wished.

Objections have been raised to this method by the concessioners on the grounds that they would have no idea how many passengers to plan for during a river running season; consequently they would be forced out of business. Private people counter with the idea that there are too many concessioner companies as it is, and that having twenty-one river-running companies is like having twenty-one telephone companies that offer the same service. Concessioners point out that there is at least some difference in their services because the nature and length of their trips and the types of boats they use differ. Private boaters object to the plan on the grounds that it is open to cheating, by both sides, inasmuch as one's chances for winning in the lottery would be enhanced by filing multiple applications or applying under false names or the names of friends who, if chosen, would yield up their places.

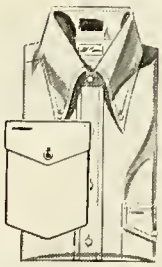
Another proposal calls for amending the Concessions Act in such a way as to specify that there must be no allocation between private and commercial use of any rationed (that is, permit-requiring) public lands under National Park Service jurisdiction. A good deal of political objection could be expected if this were adopted.

A satisfactory solution to the problem must involve the protection of the canyon and the rights of those who use it. But such a solution will never be reached if the National Park Service abdicates its role of leadership and education and continues to behave as if the opinions of concessioners reflect the opinions of the public. □

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Resisting Pollution

We have no vaccine against it: our immune system evolved to stave off living creatures

The human body's immune system, its prime defense mechanism, has evolved to a point of extraordinary sophistication. Its cells and secretions are capable of identifying, attacking, killing, and disposing of such complex structures as bacteria, parasites, and malignant growths. It is prepared to recognize as foreign, proteins and carbohydrates originating from an organism with a different genetic makeup, whether human, animal, plant, or virus. Except in the case of identical twins, it rejects organ transplants from other human beings. Organ transplants only became possible after we had learned how to suppress the immunological reaction with drugs and radiation. Transplant rejection, however, is still a common phenomenon.

The immune system can effectively recognize threatening organisms or chemical compounds that it has never encountered before. In the past, biological aggression represented a major threat to human well-being, but our evolutionary history has had handsome cooperation from scientific history. Our resistance to biological aggression has been immeasurably improved by better nutrition, improved living conditions, and advances in epidemiological knowledge. Antibiotics and vaccines now effectively protect us against many diseases and viruses that once crippled or killed us, reducing the importance of biological aggression as a selective mechanism.

No sooner had we stabilized this balance in our favor, when our technology shifted it by introducing new threats. Despite their extraordinary arsenals, our bodies seem ill-prepared for the twentieth century. They have difficulty fending off assaults from the legacy of the industrial revolution: smoke, radiation, food additives, polluted water, and industrial chemicals such as asbestos and vinyl chloride.

Today, our bodies are expected to ward off much greater quantities of pollutants in much purer form. These pollutants bypass not only the protective walls of the skin and mucosae but also the detoxification mechanisms of the liver and kidneys. Some of the new organic chemicals that are being synthesized almost daily can cause cancer, sterility, birth defects, damage to the nervous system, and respiratory diseases such as emphysema. These poisons contaminate almost half of their victims in their places of work. Thus, if dye and rubber workers, coal and uranium miners, or textile and chemical workers develop cancer, these people are ill because their bodies cannot cope with their environments.

Ironically, unlike living organisms, which are recognized and destroyed by the immune system, these industrial pollutants, which can overcome our natural defenses or actually damage them, are incapable of reproducing themselves in our bodies. Pollutants are smaller and simpler than proteins, carbohydrates, and lipids, the major constituents of living matter. Proteins are made of chains containing hundreds of amino acids. Carbohydrates result from the combination of many simple sugars. Lipids are made of several fatty acids with long chains. The new organic chem-

icals, however, are mostly hydrocarbon derivatives with short chains and benzene rings. Most of these rings contain halogens (fluorine, chlorine, bromine, and iodine) and are rarely found in living matter.

The human immune system can vanquish the highly complex flu virus, made of thousands of amino acids and nucleic acids. But we are susceptible to a simple chemical such as DDT, which is composed of only 14 carbons, 9 hydrogen and 5 chlorine molecules. An important difference between flu virus and DDT is that the latter was not present in our environment until very recently, and consequently was not a selective pressure during the evolution of our immune system. Had we been exposed several million years ago to DDT and other recently synthesized chemicals, our cells might have developed means of breaking these substances into harmless byproducts.

But the process of natural selection took place in an environment where the main threat to living organisms came from other organisms. Physical and chemical conditions at a given site, such as the ocean floor or river waters, remained constant for long periods of time. Meanwhile, the area's population changed unceasingly. New arrivals continually appeared, bringing to the scene new tastes, properties, and abilities. Within the biological community, the survival of members already adapted to the physical milieu depended on the kind of relations they maintained with others. In the past, biological aggression—one creature against another—may well have predominated over other forms of selective pressures.

In order to survive, each organism had to fix its own biological boundaries. To live, it had to take in beneficial elements such as food, oxygen, and water. But no poisons, no stranger organisms, could be allowed to trespass into an organism's precisely structured biochemical self. At all times, each entity had to be able to discriminate between its own territory—its self—and its surroundings, or nonself. Our own line of demarcation between self and nonself consists of the skin and the mucosae (the lining of the nose, lungs, mouth, and intestinal tract). If individual organisms lacked this ability to define their own space, all forms living in a certain place could fuse into a huge blob, becoming indistinguishable and entirely destroying the chances for a successful evolutionary process, which requires multiplicity and variability.

Even the simplest life forms have developed alert and attack mechanisms that can accurately tell nutrients from enemies, allowing the former in and keeping the latter out. An amoeba, a unicellular animal, is able to engulf several particles found in its environment, but it will not ingest other amoebas. Recognition structures on its exterior membrane enable this relatively primitive organism to avoid fusing with or eating its fellows.

In higher animals, these discriminating structures become much more organized and complex. The human immune system is made up of several blood serum proteins and cell types, including phagocytes, scavenger cells that resemble amoebas. All circulate throughout the body and fend off invading organisms, the body's own dead cells, and some kinds of foreign matter.



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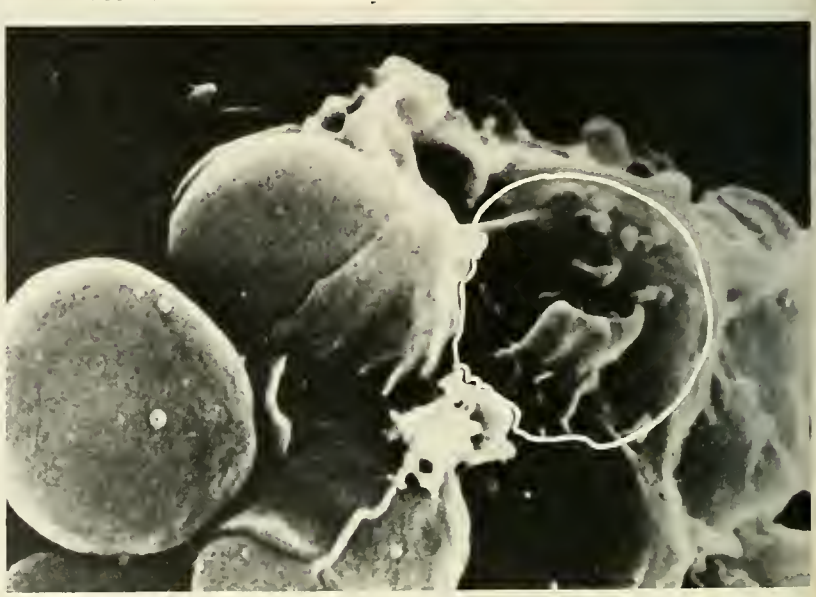
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Their concerted action leads, in a successful immunological process, to the invader's destruction.

The body's response to a commonplace injury, such as a thorn prick, illustrates the immune system's beauty and complexity. A thorn (actually another organism's defense mechanism) could have wounded our earliest ancestors, gathering fruit in Africa, as easily as it could hurt a modern raspberry picker. (Russian biologist Elie Metchnikoff first discovered the immune system in the late nineteenth century by using a thorn to prick a starfish.) The thorn punctures the defense barrier of the skin, allowing many microorganisms present in the environment to penetrate the body. The most common invaders are streptococci and staphylococci bacteria. Their entry triggers an immediate inflammatory reaction. The sufferer feels pain and heat around the wound, which swells and reddens. Blood serum molecules react chemically with the invader and summon thousands of white blood cells into the lesion. Like the amoeba, polymorphonuclear phagocytes recognize, engulf, and digest the invaders, or antigens. In the process, many phagocytes are killed by toxic substances produced by the rapidly dividing bacteria. Dead cells, tissue debris, and bacteria form pus.

In the second stage of an immunological reaction, another group of white cells known as B lymphocytes migrates through the blood to the inflammation. On their exterior membranes, B lymphocytes carry antibody molecules that bind tightly to the antigen, as a lock fits around a key. Although each B lymphocyte carries a lock that will precisely fit one key, the vast population moving through a normal human being can recognize at least one million different nonself antigens. Programmed in DNA, these locks are passed from generation to generation. We do not possess all these lymphocytes in great numbers at once, but if our system is confronted with an unfamiliar antigen, it will continue pulling out cells until it comes up with an effective antibody.

When lymphocytes carrying the specific lock meet their corresponding antigen, they proliferate into daughter cells. This large, identical progeny starts secreting enormous amounts of the same antibody into the body's blood serum. These antibodies not only help combat the present infection but also remain effective in case the same invader appears again. This characteristic is what makes vaccination possible. Vaccine, an attenuated form of an antigen, induces protective antibodies, which remain in the blood ready to ward off higher doses of the invader.



A macrophage, or scavenger cell, has ingested a red blood cell, indicated by outline, and advances on other red blood cells that have been coated with antibody.

Alfred Ehlenberger, Jean-Paul Revel

If the immune system must deal with living cells larger than bacteria, it employs another group of lymphocytes, the T. In fact, B and T cells often cooperate. T lymphocytes produce killer daughter cells that are largely responsible for destroying transplants and virus-infected cells.

In the final stages of an inflammatory reaction, macrophages clear the way for new tissue growth. Macrophages are phagocytic cells with lysosomes, small stomachs containing digestive enzymes that rid the body of its own damaged or dead cells. Macrophages also recognize and ingest certain particles.

Sometimes a biological invader is not cleared and the body becomes diseased, either because its immunological response is weak or because the parasite (which like all living things is constantly evolving ways of surviving) has adapted itself to avoid recognition or phagocytic destruction. But when an immune reaction is successful, the body's battle is over within a few days. The foreign invaders have been killed, tissue damage has been repaired, and should the same biological aggressor attack in the future, the body will be better prepared. If, however, the invader is a synthetic chemical such as DDT, the outcome is not so felicitous. To trigger the body's defenses, an invading molecule must be of a certain minimum size. Much smaller than viruses or bacteria, DDT can slip past lymphocytes and macrophages. It is not broken down by enzymes, and no antibody is formed against it. It is simply not recognized as an aggressor, as nonself.

Because they are not broken down, DDT and many other chemicals can enter the food chain. Besides their general toxic effect, certain organic chemicals can directly attack the cells of the body's immunological system. Hence they not only cause damage themselves but also interfere with immunological responses to other aggressors. Some chemicals that can work this way are dioxins, produced during the synthesis of preservatives and herbicides. Having no enzymes to break down dioxins, the body retains them for long periods.

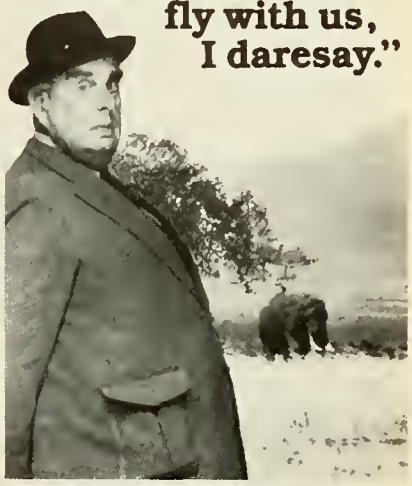
Some natural substances that phagocytic cells normally recognize can also cause disease when we are exposed to them in very large quantities. Lung macrophages can ingest some substances such as coal and silica but cannot degrade them. The scavenger cells die, and the lungs' protective mechanisms —coughing and ciliary movements —sweep out small quantities. But industrial workers who breathe in excessive amounts of particulate matter can develop serious lung problems.

Industrial pollutants constitute a selective pressure that we are physiologically unprepared to handle at present. Since some of these new materials affect our genetic material, they can cause mutations. Theoretically, over time, we could expect populations capable of resisting pollutants to appear within the human species. Unfortunately, there are inarguable objections to allowing nature to take its course. First, we do not want to deliberately bring deformed beings and monsters into the world; in any case, we have no guarantee that an immune population would indeed appear. If the pollutant is particularly strong or is present in great quantities, entire populations could be wiped out, leaving no resistant survivors—as has happened in some epidemics of smallpox, yellow fever, and cholera. And second, evolution is a glacially slow process: a single change in an amino acid's position may easily take millions of years to become a species' norm. Considering the rate at which new chemicals are being synthesized, we would be obliged to develop adaptive mechanisms in an impossibly short time.

Evolution may provide an explanation for our inability to deal with pollutants, but it is not a feasible answer to their challenge. Rather than waiting for biological adaptation to a new environment, we must insure that the environment suits life. If we adapt the industrial revolution to life on earth, we can avoid a growing number of diseases caused by environmental factors. A preventive approach may be less spectacular, but our reward will be less disease and fewer deformities —in short, a better life.

Celso Bianco is an immunologist at Downstate Medical Center, State University of New York, Brooklyn, New York.

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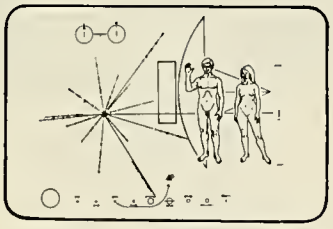
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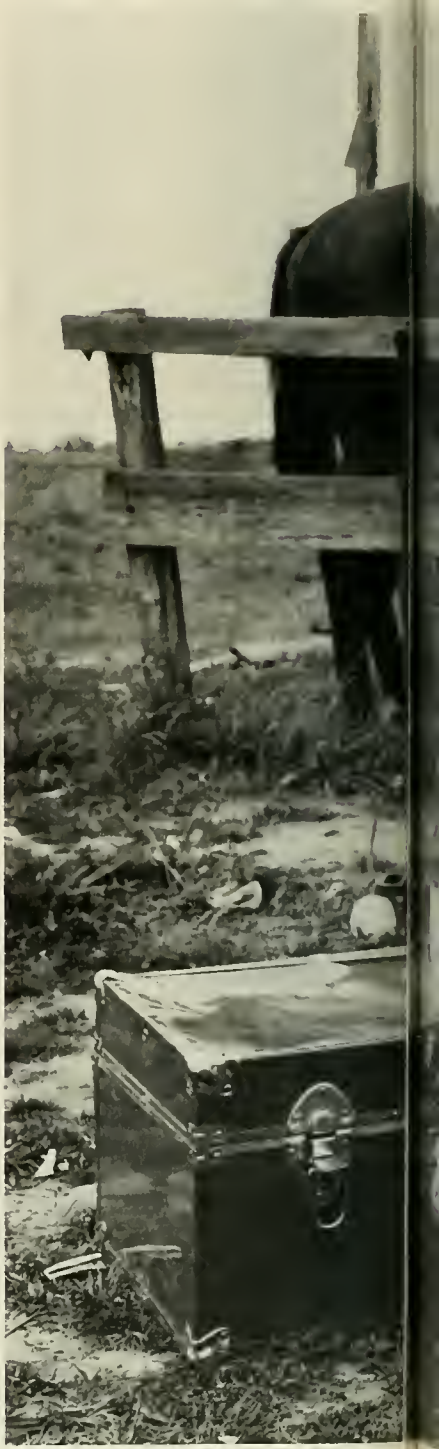
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Cajun Country

LOUISIANA CAJUNS/CAJUNS DE LA LOUISIANE, photographs by Turner Browne, text by William Mills. *Louisiana State University Press, $14.95; 101 pp., illus.*



The Louisiana Cajuns, a people whose ancestors first settled in southern Louisiana in the mid-eighteenth century, today inhabit the prairies and bayou country of the southwestern part of the state. Many of the Cajuns' traditional customs and much of their way of life remain well intact, and this book offers the reader a firsthand look at them. Although it is not apparent from its title, the book comprises a number of splendidly composed photographs by Turner Browne (a native of south Louisiana, now a professional photographer in Los Angeles), whose purpose was "to get some good scenes on film before they disappeared." The work contains, in addition, a lively introductory essay by noted Louisiana poet William Mills, which provides background material for the photographs. The text and photo captions are in both English and French, with the French texts rendered by James and Elisabeth Spohrer. The result is a fascinating volume that introduces the reader to the life, culture, land, and people of south Louisiana.

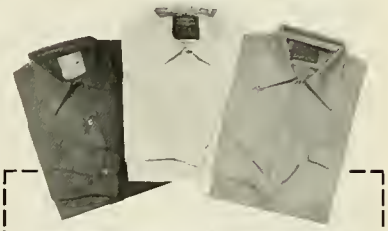
The reader expecting to learn about the Cajuns in prose may be mildly disappointed, as Mills's introduction attempts only a brief résumé of these people and their life ways. Yet his remarks seem more than adequate in providing a context in which to view Browne's photographs. Since the photographs and captions actually make up the main body of the book, the latter can only be judged as a visual, pictorial contribution. Thus with *Louisiana Cajuns*, one finds neither an academic research monograph nor a journalistic photoessay, but rather a sensitive and searching

by Steven L. Del Sesto



Young jockey waits between races

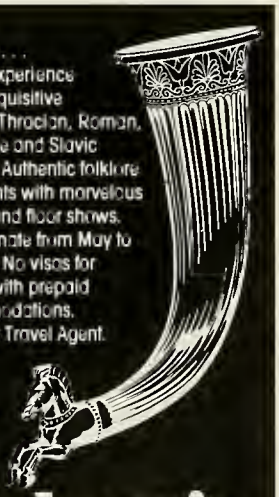
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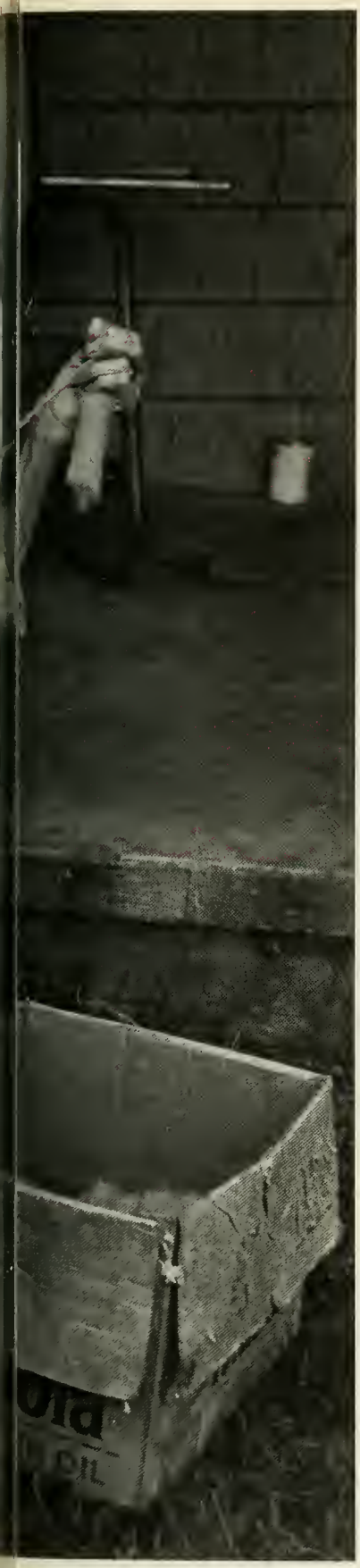
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Cajun woman, ninety-three years old, still grows and spins her own cotton



work of art that attempts to capture and preserve, through visual images, what it means to be a Cajun.

Turner Browne has done his job well; his selection of photographs gives the reader an understanding of the unique social life and cultural customs of the Cajun people. Perhaps most distinctive among these customs is the Cajun penchant for the good times, captured in Browne's photographs of traditional Mardi Gras celebrations still found in the rural villages of Church Point and Mamou. Similarly, the photos of Zydeco musician Clifton Chienier, performing before a wild, foot-stomping audience at the backwoods honky-tonk Jay's Lounge; or of Cajun accordionist Nathan Abshire dancing a little jig onstage before some 12,000 spectators at the first annual Acadian Music Festival held in Lafayette in 1974; and of people dancing in the streets of Breaux Bridge at this little town's yearly Crawfish Festival—all give the feeling of the good time spirit for which the Cajuns are known. There are also some enjoyable photographs of women competing in the annual muskrat-skinning contest in Cameron's Fur and Wildlife Festival, the men's competition in the trap-setting contest, and the annual pirogue races held on Bayou Lafourche.

Yet juxtaposed against this backdrop of merrymaking and revelry, Browne probes further to reveal the fundamental intensity and seriousness of the Cajun people. His photographs of the constant struggle to contain the treacherous floodwaters of Atchafalaya Swamp, which inundate roadways and constantly threaten small rural towns and villages; of the backbreaking work of a Cajun trapper pursuing valuable nutria pelts in the desolate marshlands of the Gulf of Mexico; or of men and women struggling with a three-hundred pound hog at an old-style, do-it-yourself country *boucherie* ("butchery") tell of the unremitting toil that characterizes the Cajun way of life. Perhaps most revealing in this context is Browne's scene of a sizable cash deal between a Cajun trapper and his buyer, where the buyer admits that "on a full day of buying I have to carry ten, twenty thousand dollars cash. . . . I also carry two shotguns and a pistol."

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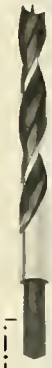
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The cutting edge between work and play, between seriousness and good times, however, is probably best fused in the Cajun view of chance and the surreal. Games of chance abound in Cajun country, and Browne has provided a number of candid shots of sub rosa cockfights and parallel quarter-horse racing in the rural areas; events, it might be pointed out, that scarcely enjoy the legal sanction of the state. In the same vein, Browne offers a number of thoughtful compositions of rural faith healers, fortune tellers, and even a woman practitioner of voodoo concocting a potion of salt, gunpowder, saffron, and dried



Crawfishing in the Louisiana swamp

dog dung—undoubtedly to ward off some evil spirit, or *gris-gris*. Although plainly serious, the people in these photographs nonetheless seem placid, perhaps expressing a mindful awareness that games of chance and belief in the surreal provide a means of dealing with uncertainty in more comprehensible terms. As Mills puts it: "So [the Cajun] played games of chance and expressed ritualistically a cavalier disdain for hazard, somehow gaining a magic control over his fate."

Finally, I think the book fulfills very well its primary goal of getting some "good scenes on film before they disappeared." Yet I wonder if Browne is actually right about the inability of the Cajun people to withstand the leveling standardization of mass culture. The poise and sheer determination on the faces of his subjects; their effervescent enthusiasm and love of life, displayed so brilliantly on film; and the technologically untamable wilds of southern Louisiana's geography and climate suggest the Cajuns' disappearance is no sure bet. Thus, more than any other photograph in the book, I think one in particular leaves Browne's prognosis in partial doubt, at least in my mind. This is the photo of Kenneth Richard, guitar in hand, sitting with his father, Felix, in the family room after Sunday dinner. Kenneth listens intently to his father's old-time accordion, learning to play "some of the almost forgotten music of his forefathers." No doubt Felix Richard learned the music in much the same fashion, just as Kenneth will perhaps teach his own children someday. With this photograph, I think Browne himself tells us part of the reason why his prophecy may not prove correct. Nevertheless, Browne has produced for us a compelling visual guide of the land and people of southern Louisiana. For those interested in a sensitive, truly authentic vision of the Cajuns of Louisiana, Browne's book offers a welcome clarity seldom achieved in works of this sort.

Steven L. Del Sesto, a member of The Department of Sociology at the University of Rhode Island and at Brown University, is coeditor of The Culture of Acadiana: Tradition and Change in South Louisiana (1975) *and the forthcoming* Essays on the Culture of Acadiana.

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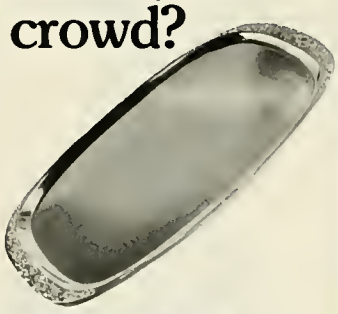
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A Matter of Taste

How to Cook a Snoek

Recipes and food customs are true artifacts of a culture

Miss Hildagonda Duckitt made her own soap from sheep's tallow. When hands on her farm in the Darling district of South Africa came down with jaundice, she steeped them a cup of dagga, or marijuana tea. For sore throats, the intrepid Hildagonda prescribed and herself prepared Hottentot fig gargle. She flourished about 1900 as a sort of Cape Colony Mrs. Beeton.

Her two bestsellers—*Hilda's Where is It?* and *Hilda's Diary of a Cape Housekeeper*—record the whole delicious and polyglot range of the mixed, Creole cuisine that sprang up near Capetown in the nineteenth century. Nowadays, such Dutch-Malay specialties as *sasaties* (kebabs) and *tameletjies* (tangerine sweets) have, evidently, all but vanished from South African tables. Fortunately, Miss Duckitt could write, was published, and even reprinted in 1951. And so it was a matter of relative ease for Sheila Patterson to reconstruct the alimentary life of South Africa during colonial days. Other anthropologists, examining cultures without written cookbooks, had to roll up their sleeves and cook with villagers all over the world in order to gather contributions for Jessica Kuper's valuable new anthology, *The Anthropologists' Cookbook* (Universe Books).

Here is a book crammed with useful gleanings and nourishing insights into exotic cultures. Naturally, some of the foods will not appeal at all to American readers. Naomichi Ishige understands that roasted dog, even as prepared on Ponape in the Caroline Islands—in an earth oven, with breadfruit and pork—will horrify most of us. Ishige writes, however, that "the dog did not taste as bad as its smell would have led one to believe . . . and, looked at through alien eyes, our attitudes [against eating dogs] can only seem to be a kind of fetishism."

This is an extreme case, but it illustrates with particular clarity how food—and attitudes about food—separates one culture from another in ways that run far deeper than matters of taste, sensorially conceived. Claude Lévi-Strauss, in an essay excerpted from *L'Origine des manières de table* (forthcoming soon in an English translation), recalls that after the Normandy invasion of 1944, it became clear that "American soldiers had a broader conception of the category of the rotten than the French; under the impression that the Normandy cheese dairies stank of corpses, they sometimes destroyed the buildings."

Professor Lévi-Strauss is, of course, primarily interested in symbolically universal food customs and attitudes. Whether or not such universals do exist, and even if they do constitute, as Lévi-Strauss asserts, "a culinary universe, which is a miniature reflection of the cosmos," most of the information compiled for the Kuper anthology leads us firmly down to ground level.

Isobel White gives an extraordinarily vivid sense of her life among Australian aborigines in a detailed recipe for damper, a disk of bread baked in ash over wood coals. She begins, "Retrieve your axe from whomever has borrowed it," and then describes building a campfire with local acacia pieces left over from woodworking. Step 2 starts, "Find a large pan. This may be the hardest task of all. In a society unused to such items, there never seems any place to keep them in the native bough shelters. In any case no woman can refuse to lend hers to a neighbor or refuse to hand it to any

by Raymond Sokolov

young child who wants it to make play dampers of earth and water. Having found a pan and shaken off the sand or dirt put there by the child, put in some flour, some salt, and some baking powder ('some' means about 5 lb [2.5 kilos] flour, a couple of tbsp. baking powder . . . and the same of salt)." Next, Ms. White discusses the problems of finding water or, for that matter, a bucket; of keeping children out of the flour; of remembering not to ask a man or boy to fetch water since water carrying is demeaning for males. Given these realities of aboriginal life, the actual mixing and kneading of a stiff dough into a large bicycle-size wheel two inches thick sounds relatively simple. Dogs, too, interfere. "This anthropologist," remarks Ms. White dolefully, "once lost the whole of her supper while her back was turned for seconds."

Not all anthropologists pursue fieldwork in such technologically primitive locations. But the thrust of anthropology toward what seems primitive by Western standards can push a researcher toward premodern survivals in more or less industrialized cultures. In contemporary rural Spain, Susan Tax Freeman investigated the details of old-fashioned pig slaughter, called *matanza*. This was not a capricious enterprise; indeed, it yielded what seems to me the outstanding piece of research in the Kuper collection.

Freeman was acute enough to see a cultural discontinuity between contemporary Spanish cities and farms in the specific area of pork cookery. No doubt there are many such gaps appearing in Spain's social fabric as the country belatedly joins the rest of modern Europe and finally turns its back on the nineteenth century. But the *matanza* is an especially clever focus because it draws together elements of preelectrical technology—dodges for dealing with an entire pig *en famille* and without refrigera-



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tion—as well as providing urban cooks in Spain and elsewhere with information (largely isolated or lost from view) on how to cure hams without smoking, how to stuff the pungent chorizo sausage, and how to dry and preserve marinated pork ribs and loins. Many cultures have similar processes for meat preservation, but Spain developed its own, and it imparts a characteristic, Spanish country flavor to certain dishes. This flavor is an artifact as surely as the Alhambra, and it should be conserved with as much care.

It should be obvious, also, that recipes keep better than buildings, develop no dry rot, and do not crack or fade like a Velázquez. And anyone can prepare dried mountain ham (*jamón serrano*) at home since it does not require special smoking equipment.

According to Freeman, you simply take a fresh leg of pork with the skin on, lay it on a bed of salt in a box or a basin with a hole for drainage, cover it with salt (coarse-grained, but not rock salt), and leave it uncovered in a cool, airy place for as many days as the leg's weight in kilograms. Then wash off the salt and press the leg under two cases of wine for five to twelve days (less pressing is needed if the conditions are especially dry). Coat the pressed ham with a paste of sweet paprika wetted with a small amount of vinegar. Hang on a meat hook for six months (the hole for the hook should be filled with ground black pepper and the knuckle should be generously coated with pepper to keep maggots away). (In areas where trichinosis is present, the meat should only be used in cooked dishes and never eaten raw.)

All this was done by Spanish country folk with a minimum of ceremony. For elaborate food ritual, one may turn to Laos, where Alan Davidson, quoting F.H. Giles's account of the ceremonies performed before catching the giant catfish of the Mekong, mentions propitiatory rites for the spirit of the Golden Basin that required "a procession of boats conveying swords, water gourds, trays of betel-nuts and leaves, pieces of silver and of beeswax, green coconuts, sweetmeats, candles, incense tapers, sandalwood flowers, a gong and two flutes, all to be offered to the Spirit with suitable music and incantations.

"One wonders," writes Davidson, "how the fishermen, preoccupied by the need to do everything right, could devote the necessary attention to the actual catching of fish. They would be further distracted by the requirement that they should hurl abuse at each other throughout the fishing: 'O, bald-headed fool; O, ancients in thy dotage. A dog shall lie with thy mother. . . .' "

Supposedly, the advent of motorboats scared off the fish and ended the abundant conditions that encouraged such a leisurely approach to fishing. Everywhere, the old chain of food transmission from farm to table has been disturbed and distorted. Built up at a glacial pace over centuries, food customs and recipes are the epitome of the traditional life in every culture. Their loss is not merely a sign of gastronomic decline, for if that was all it meant—inferior hams—who would seriously care. The problem is one of social pathology. Spain barrels into the present, leav-

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ing its self-sufficient, farm-family ways behind. Motorboats roil the Mekong and the Laotian spirit. In South Africa, riots and avarice replace Hildagonda Duckitt's homegrown quinces, tortoise soup, and "sea-fresh *snoek*" (rock lobster), which the doughty dame learned to cook from her mother and an ex-slave from East Africa called Abraham.

Happily, all is not lost. Some people care about these fading continuities. And those who do, not just the ones with Ph.D.s, should be called anthropologists. It is a favorable sign that this book has appeared. As Mary Douglas says in the introduction, "Food is not feed. Let this be a beginning to a systematic anthropology of food."

Meydiha's Kisir

(Based on Marianne and Jerry Leach's transcription of a Turkish cracked wheat dish.)

12 scallions, white and green portions, trimmed and chopped
2 cloves garlic, peeled and finely chopped
6 tablespoons olive oil
1 pound (about 2½ cups) cracked wheat (bulgur)
1 tablespoon tomato paste
¼ teaspoon cayenne if you like pungent tastes—or red pepper if you don't. (Note that the tomato paste and cayenne are a substitute for the liquefied tomato paste and chili pepper pulp found in southern Turkey. The substitution maintains some authenticity because red pepper and cayenne come from the same species as Turkish chili peppers.)
Black pepper
Salt
4–8 ounces (1–2 bunches) parsley (preferably the flat-leaved, Italian variety), finely chopped
¾ cup lemon juice (juice of 3 small lemons)
Romaine lettuce
3–4 lemons, sliced into wedges

1. Sauté the scallions and garlic in the olive oil until the scallion pieces have softened but not browned.
2. Combine the sautéed scallions, garlic, and olive oil with cracked wheat in a large pot. Stir until the wheat has been coated with the oil and absorbed it all. Pour 5 cups of boiling water over the cracked wheat mixture. Bring to a boil, stir in tomato paste, reduce heat, cover, and simmer slowly until water has been absorbed and the wheat is soft and fluffy. This will take about 15 minutes, but check beforehand so that wheat does not overcook and turn mushy.
3. Stir in seasonings, parsley, and lemon juice. Cover and let stand until ready to serve. The flavor deepens the longer it stands. There is a limit to this if you wish to serve the *kisir* hot. It is quite palatable as a cold dish, but is traditionally served steaming on a bed of romaine leaves with lemon wedges. (Bulgur can be reheated. Just add a small amount of water and place, covered, over very low heat.)

Yield: 6 servings as a main course

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.

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The Eggshell's Story

photographs by David Scharf

From a distance, an egg looks elegantly simple. Its smooth, rounded surface encloses life's beginning, suggesting sustenance and a new day's start. But close examination shatters the egg's tranquil disguise. Under the power of a scanning electron microscope, an egg's surface resembles a vast field of broken ice. An even closer view turns out to be very dramatic: what was a hairline crack in the eggshell now appears to be a fissure dividing a small cathedral. The slight fault yawns away into a deep canyon.

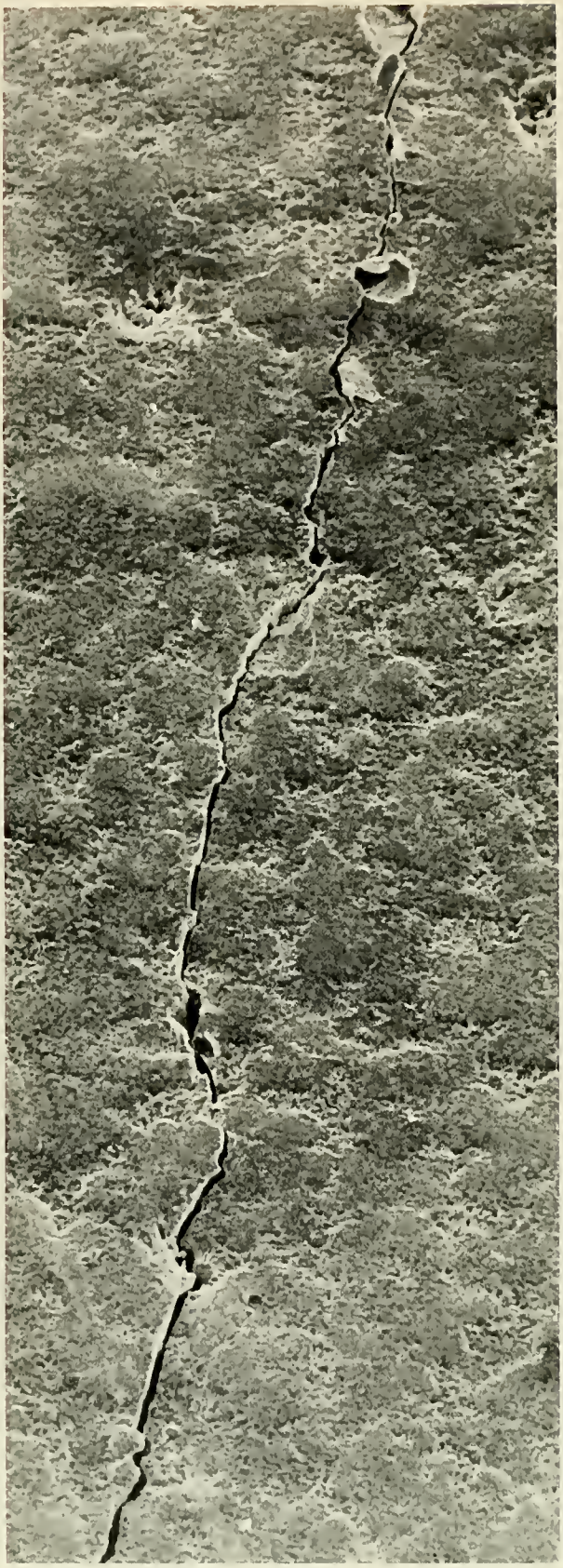
An egg's shell is not only a protective shield; it also allows the egg to breathe. If the egg's embryo is to survive, oxygen must pass in, and the carbon dioxide metabolized inside must pass out, through the shell. Inside the shell, the yolk and white are bound together and enclosed by two swaddling membranes, made up of cobweblike fibers. The fibers of the outer membrane are firmly threaded through the cores of small knobs, or mammillae, which fuse to form the eggshell's inner layer, and the membrane is anchored like a fishing net to these knobs. The rough tips of the mammillae form a mossy looking surface that continues into the shell's outer layer. This part, the palisade layer, is composed of calcite, a crystalline form of calcium carbonate. Closely packed columns of these crystals, fitting together like pieces of a puzzle, are further connected by a matrix of protein. Between the columns are air chimneys ending in pores, which an unaided eye can see in the small depressions on an egg's surface. The shells of domestic hens' eggs vary tremendously in thickness and number of pores, but generally the egg's broad end has more pores.

Just before the egg is laid, it is polished off, like a dyed Easter ornament, by a cuticle coating. Depending on its parent, the egg may turn out speckled, pink, almost black, terra cotta, dull, porcelainlike, glossy, chalky, ridged, pitted, soapy, or even oiled for extra waterproofing. However, all eggs, from those of the tiny, fragile hummingbird to the tough, enormous specimens of the extinct elephant bird, require shells of the sturdy but porous nature revealed in these photographs.

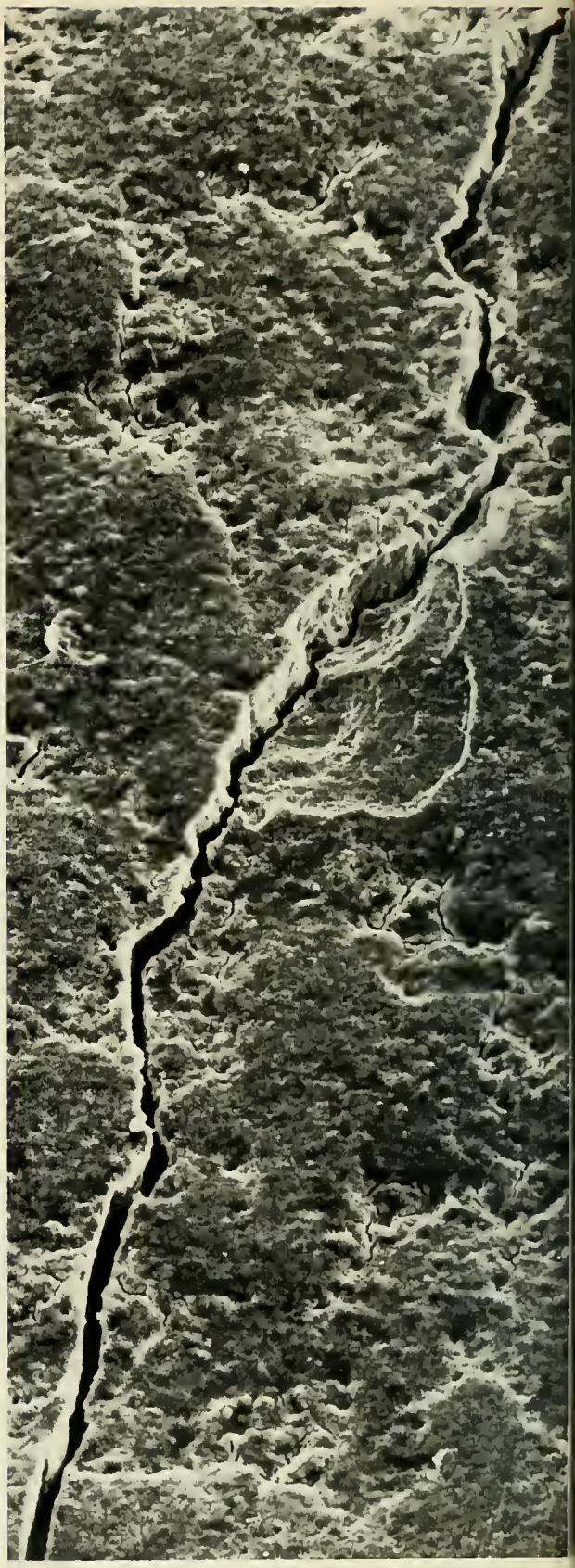
Ann Marie Cunningham



All photographs through Peter Arnold Photo Archives



120x



600x



200x

Celestial Events

by Thomas D. Nicholson

Sun and Moon In early March, the sun is south of the equatorial plane, moving eastward through the stars of Aquarius. It enters Pisces about March 12, crosses the equator on March 20 (the vernal equinox), and moves into Aries about April 19. As the sun's motion takes it rapidly northward, there is a marked increase in the duration of daylight and insolation in the Northern Hemisphere.

The moon appears in the evening sky as a slender crescent, following the sun into the western horizon, on about the 10th or 11th of both March and April. It remains a prominent early evening object until the last week of both months. In March, first-quarter moon is on the 16th, full moon on the 24th, and last-quarter on the 31st. After the new moon of April 7, first-quarter is on the 15th, full moon on the 22nd, and last-quarter on the 29th. Perigee moon is on March 5 and 31, apogee on March 17 and April 14.

Stars and Planets The trend of the planets to shift into prominence as evening stars continues in March and April. All except Pluto are above the horizon at sunset until mid-April, and even Pluto becomes an evening object on April 5. During the last two weeks of March, Mercury will be favorably placed from mid-evening to late twilight; Venus, much brighter and easier to see, will be nearby to serve as a guide. Look for Venus, bright and low in the west, from half an hour past sundown until dark. Mercury will be almost directly above it on the evening of the 15th; dimmer and more distant on subsequent nights. And, while Mercury becomes less prominent (you can't expect to see it after the end of March), Venus becomes more noticeable in the evening sky of April, appearing higher and setting later.

Jupiter, Mars, and Saturn will be arrayed from right to left among the dominant constellations of the evening spring sky. At dusk in March, Jupiter, the brightest of the three, will be high in the south in Taurus. In April it moves into Gemini. Mars is to Jupiter's left until late March; then moves into Cancer. Saturn is farther to the left, in Leo, just to the right and a little brighter than the star Regulus.

March 2: Mars resumes its direct (easterly) motion, shifting to the left relative to the bright stars of Gemini.

March 12: Mercury and Venus are in conjunction today.

March 16: Jupiter is near the moon this evening.

March 18: Mars is near the moon tonight.

March 20: Spring commences in the Northern Hemisphere at 6:24 P.M., EST, when the sun arrives at the vernal equinox.

March 24: A total lunar eclipse today will be visible in North America, but only in the extreme northwest. Mercury, at greatest distance to the sun's left, is favorably placed as an evening star.

April 1: Mercury begins its retrograde motion.

April 8: Venus is close to the crescent moon tonight.

April 11: The occultation of Aldebaran by the crescent moon will occur in daylight over eastern Canada. Mercury, in inferior conjunction, enters the morning sky.

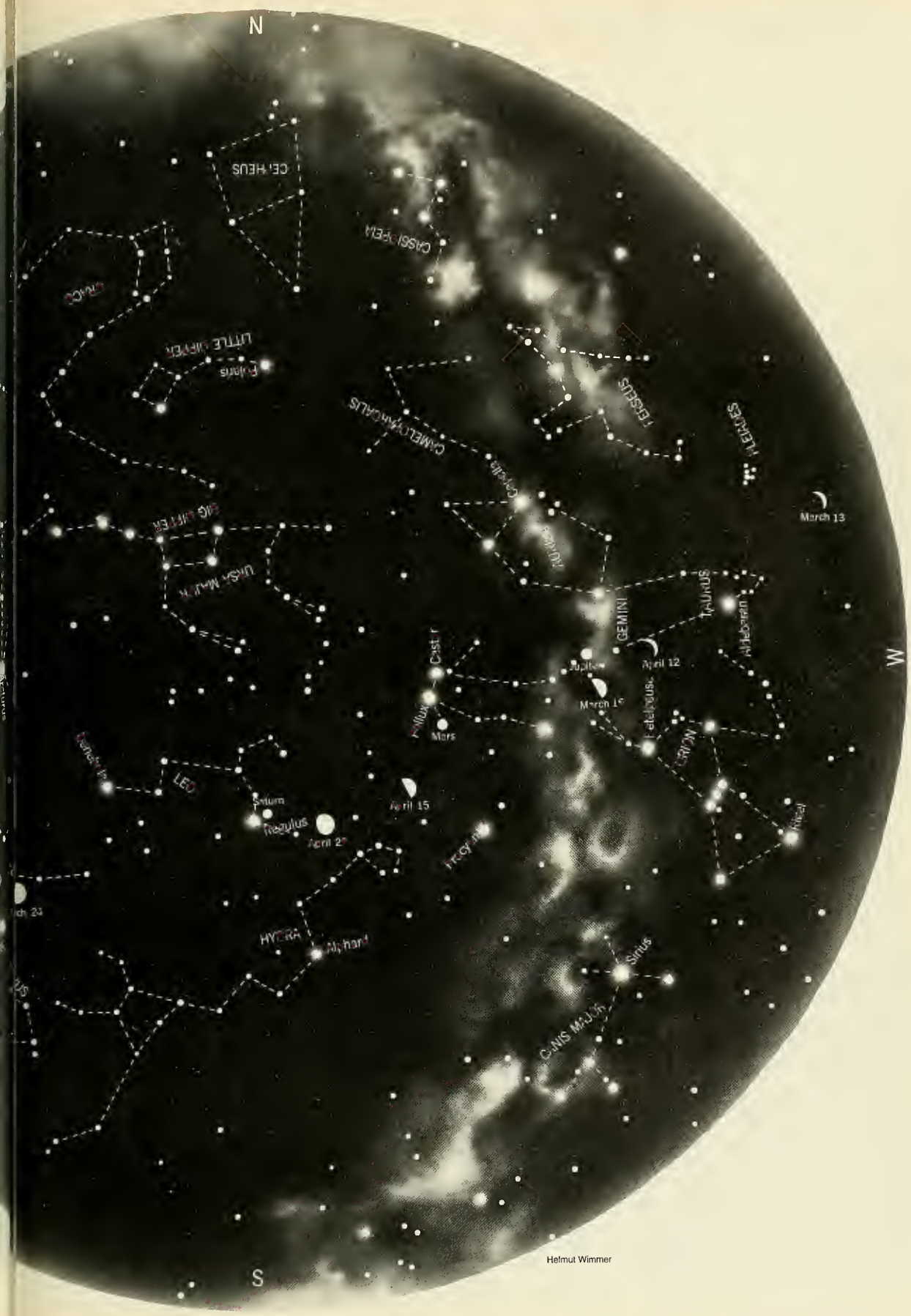
April 12: Jupiter is near the moon tonight.

April 15: Mars is near the moon tonight.

April 17: Saturn is near the moon tonight.



★ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:20 P.M. on March 1; 10:25 P.M. on March 15; 9:20 P.M. on March 31; and 8:25 P.M. on April 15; but it can also be used for an hour before and after those times.



Helmut Wimmer

Additional Reading

Thoreau (p. 6)

Much has been written about Thoreau but the two most recommended biographies are *The Days of Henry Thoreau,* by Walter Harding (New York: Alfred A. Knopf, Inc., 1965), and *A Thoreau Profile,* by Milton Meltzer and Walter Harding (Concord: Thoreau Foundation, Inc., 1969), in paperback for $4.00. Most of Thoreau's works are available at the Thoreau Lyceum, 156 Belknap Street, Concord, Massachusetts 01742, which carries copies of *Cape Cod, The Maine Woods,* and *A Week on the Concord and Merrimack Rivers,* for less than $5.00 each. A good sampling of Thoreau's famous journals can be enjoyed by reading a $2.75 paperback, *The Heart of Thoreau's Journals,* edited by Odell Shepard (New York: Dover Publications, Inc., 1960).

Mexican Bats (p. 50)

The Biology of Bats, edited by William A. Wismatt (New York: Academic Press, 1970), is a two-volume work: the first covers strictly biological topics; the second, ecological and behavioral ones. While working on the problem of bite-free rabies transmission, Denny G. Constantine of the U.S. Public Health Service made a careful, five-year study of population fluctuations and group movement of Mexican free-tailed bats. This effort resulted in *Activity Patterns of the Mexican Free-tailed Bat* (Albuquerque: University of New Mexico Press, 1967), a pioneering book packed with data. Two works that represent Mexican–United States scientific cooperation on the question of migration of the Mexican free-tailed bat (an animal that knows no political boundaries) are: "Migration in the Guano Bat," by R. B. Villa and E. L. Cockrum (*Journal of Mammalogy,* vol. 43, pp. 43–64), and "Migration in the Guano Bat," by E. L. Cockrum (*Miscellaneous Publication 51,* University of Kansas Museum of Natural History, pp. 303–36). In "Bat Mortality: Pesticide Poisoning and Migratory Stress," Kenneth N. Geluso and others have provided facts and figures on the effects of pesticide concentrations, combined with migration, on prereproductive mortality rates among bats (*Science,* October 8, 1976, pp. 184–86). *The Life of the Cave,* by D. E. Mohr and T. L., Poulson (New York: McGraw-Hill Book Co., 1966), is a volume in the "Our Living World of Nature" series. Lavishly illustrated, the book covers everything from the geology, plants, and animals of caves to spelunking in them.

Medieval Women (p. 56)

Interest in women's studies has been sufficient to sustain the publication in 1975 and 1976 of two notable volumes on the subject of medieval women. The first of these, *The Role of Women in the Middle Ages,* edited by Rosemarie T. Morewedge, was published in Albany by the State University of New York Press and includes bibliographic citations for each chapter, as well as some black-and-white illustrations. This book resulted from the sixth annual conference at the Center for Medieval and Early Renaissance Studies, held in Binghamton, New York, in 1972, and attended by representatives of different disciplines who shared a common interest. The second work, by Susan Mosher Stuard, is *Women in Medieval Society* (Philadelphia: University of Pennsylvania Press, $4.95 in paperback). This collection of journal articles has the additional advantage of an introduction that Stuard prepared as a synthesis of the information contained in the articles. Each year, the University of Saint Thomas in Houston, Texas, invites scholars to speak on historical topics, and these are published as the Smith Lectures. The Smith Lecture for 1971 was David Herlihy's *Women in Medieval Society,* available for $1.50 from the History Department, University of Saint Thomas, 3812 Montrose Blvd., Houston, Texas 77006.

Maya Kites (p. 68)

Photographer Hans Namuth treats the eye to several pages of color photographs of Maya kites and three paragraphs of written information in "The Kites of Guatemala" (*Architecture Plus,* July/August 1974, pp. 64–69). "The Maya of Northwestern Guatemala," by Charles Wagley, pp. 46–100 of volume 7 of the *Handbook of Middle American Indians* (Austin: University of Texas Press, 1969) is a synthesis of basic knowledge of Maya culture in the Santiago area. The Harvard Chiapas Project, a study of the Maya, was one of the longest-running ethnological investigations ever made. Evon Z. Vogt published two notable volumes as a result of this project, *The Zinacantecos of Mexico: A Modern Maya Way of Life* (New York: Holt, Rinehart and Winston, 1970), a "Case Studies in Cultural Anthropology" paperback for $3.95, and a big, thick volume entitled *Zinacantan: A Maya Com-*

munity in the Highlands of Chiapas (Cambridge: Harvard University Press, 1969). These books are nicely illustrated with black-and-white photographs and diagrams. Both boast good bibliographies; the former also includes a "Recommended Reading" list. For information about Maya religious practices there is a chapter devoted to the topic in Octavio Paz's *Labyrinth of Solitude: Life and Thought in Mexico* (New York: Grove Press, 1962), a $3.95 paperback.

Sharks (p. 76)

Volume 3, part 3 of the *Handbook of Sensory Physiology,* entitled *Electroreceptors and Other Specialized Receptors in Lower Vertrebrates* [*sic*], by T. H. Bullock et al., was edited by Alfred Fessard, and published by Springer-Verlag, New York, in 1975. Of the nine chapters in the monograph, six focus specifically on electric phenomena and make up the latest, most complete coverage of this field of study.

The Office of Naval Research has sponsored E. S. Hodgson and R. W. Mathewson in their editing of *The Sensory Biology of Elasmobranchs,* soon to be published by the U.S. Government Printing Office. Watch issues of the *Monthly Catalog of United States Government Publications* for the announcement of its availability. This work will be an excellent source of information about people and facilities currently involved in actual research on shark sensory physiology.

Eugenie Clark, who was instrumental in creating the Cape Haze Marine Laboratory in Florida and served as its first director, wrote an account of that experience in *The Lady and the Sharks* (New York: Harper and Row Publishers, 1969). Perry Gilbert, the present director of the laboratory (now known as the Mote Marine Laboratory), contributed "The Behavior of Sharks" to *Scientific American* July 1962, pp. 60–68. General biological information is abundantly provided in Henry B. Bigelow and W. C. Schroeder's *Fishes of the Gulf of Maine* (U.S. Fish and Wildlife Service, Fishery Bulletin, 1953, vol. 53), which includes a substantial section on sharks. More general information can be found in Richard H. Backus and Thomas H. Lineaweaver's *Natural History of Sharks,* $2.95 in a 1973 paperback edition from Doubleday and Co., New York. Richard Ellis's *The Book of Sharks* takes an anecdotal, pictorial approach to the subject of shark study. Published in 1976 by Grosset and Dunlap, Inc., New York, this coffee-table-sized work boasts two-page color spreads of the author's shark paintings, as well as photographs of prominent shark specialists taken at work.

River Running (p. 82)

Several works provide a philosophical backdrop for the problems posed by river use and private versus commercial interests in our national parks. In 1974, the Conservation Foundation of Washington, D.C. produced a task force report, *National Parks for the Future.* Among other matters, this report addresses the question of overuse of the parks. Another proponent of the notion that Americans are loving their wilderness areas to death is Roderick Nash, a river runner and author of *Wilderness and the American Mind* (New Haven: Yale University Press, 1973). His book includes a discussion of Grand Canyon's difficulties and a bibliography. The history of policy making in the national parks of the United States can be approached through two sources. *Our National Park Policy: A Critical History,* by John Ise (Baltimore: Johns Hopkins Press for Resources for the Future, 1961), is a scholarly, citation-filled work, particularly useful for explaining the ideas in vogue at the time of the founding of the park system. A *Special Supplement* in the October 1976 issue of *Natural History,* "America's National Parks; Their Principles, Purposes, and Prospects," by Joseph Sax, is a summary that brings with it additional bibliographic information.

Most of the material directly related to the question of river recreation and commercial versus private river running is in the form of government documents. In January 1977, the U.S. Forest Service held a symposium on river recreation. The results, published as U.S. Department of Agriculture, Forest Service, General Technical Report NC-28, *Proceedings: River Recreation Management and Research Symposium,* may be obtained from the North Central Forest Experiment Station in St. Paul, Minnesota. Bo Shelby and Joyce Nielsen of Human Ecology Research Services, Inc., submitted *Private and Commercial Trips in the Grand Canyon,* part 4 of the "Colorado River Research Program" series, under contract to the National Park Service in 1976. This publication (PB-267729) is available from the National Technical Information Service in Washington, D.C.

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Announcements

The **Alvin Ailey Repertory Ensemble** will appear for the fourth year in the American Museum of Natural History's auditorium on March 12 at 1 and 3 P.M. Due to the popularity of this dance group, tickets will be available *only* at the first floor information desk on the day of the performance. There is a discretionary entrance fee to the Museum but no additional charge for tickets (limit 2 per person).

For 50¢, visitors to the **Hayden Planetarium** can rent a recorded tour of the three sections of the Hall of the Sun. The tour covers solar energy and the effects of the sun on the earth; the origin and nature of the sun and its relation to other stars; and a film of the best sun photographs ever made. Admission to the Planetarium is $1.35 for students and young people, $2.35 for adults over 17, and $1.50 for senior citizens, and includes entrance to the Hall of the Sun, the Guggenheim Space Theater, Astronomia, the world-famous Sky Theater (which is now showing "The Orion Star Factory"), and the American Museum of Natural History.

Olivier Gardon, a young French pianist, will perform works by Beethoven, Prokofiev, and Debussy in the Museum's auditorium on March 15 at 7 P.M. Gardon is one of many concert artists being promoted by Jeuness Musicales, Inc., in cooperation with the 1977–1978 Neighborhood Concert Series.

Matteo EthnoAmerican Dance Theater is a multiracial group of native-born Americans that performs folk dances from such places as Scotland, Hawaii, Spain, the Middle East, and India. Matteo has been highly praised for his performances of native dances in their countries of origin. His troupe has appeared at the Delacorte Dance Festival and the United Nations. On March 29 at 8 P.M., Matteo and others, including his partner, Carola Goya, and Spanish dancer Maria Benitez, will perform ethnic dances in the Museum's auditorium. Tickets for Associate Members and the public are $2, and will go on sale at the auditorium door half an hour before the program begins. Life, Donor, and Participating Members admitted free.

Through a grant from the New York State Council on the Arts, the **Library of the American Museum of Natural History** is now open to the public on Saturdays from 10 A.M. to 4 P.M., in addition to the usual hours of 11 A.M. to 4 P.M., Monday to Friday. The library, located on the fourth floor, contains approximately 350,000 volumes and receives more than 6,000 journal titles a year. Although the public cannot borrow library materials, they may use the reading room and a photocopying service is available.

A Mexican Weekend at the Museum, on March 4 and 5, will include films, arts and crafts demonstrations, and two performances of "A Clay Mask Journey," which tells how Quetzalcóatl, an Aztec god, brought music to the earth. The piece will be performed Sunday March 5 at 2 and 3 P.M., in the Mexican Hall by mask-maker Robert Sherman and dancer Sabina Nordoff, accompanied by Jim Milton on various handmade instruments.

In the People Center, located on the second floor of the Museum, Leslie Tillett will show slides and discuss his 100-foot-long tapestry, depicting the conquest of Mexico. Some of the films to be shown in the main auditorium are: *The Life and Death of Frida Kahlo,* by Karen and David Crommie; *Sabina Sanchez and the Art of Embroidery,* by Judith Bronowski; *Los Olvidados,* by Luis Buñuel; *Tree of Life,* by Bruce Lane; *Lost World of the Maya,* with Eric Thompson; and *Manuel Jimenez: Wood Carver,* by Judith Bronowski. This weekend is made possible by the National Endowment for the Arts. For further details, call the Museum at (212) 873-1300, ext. 559.

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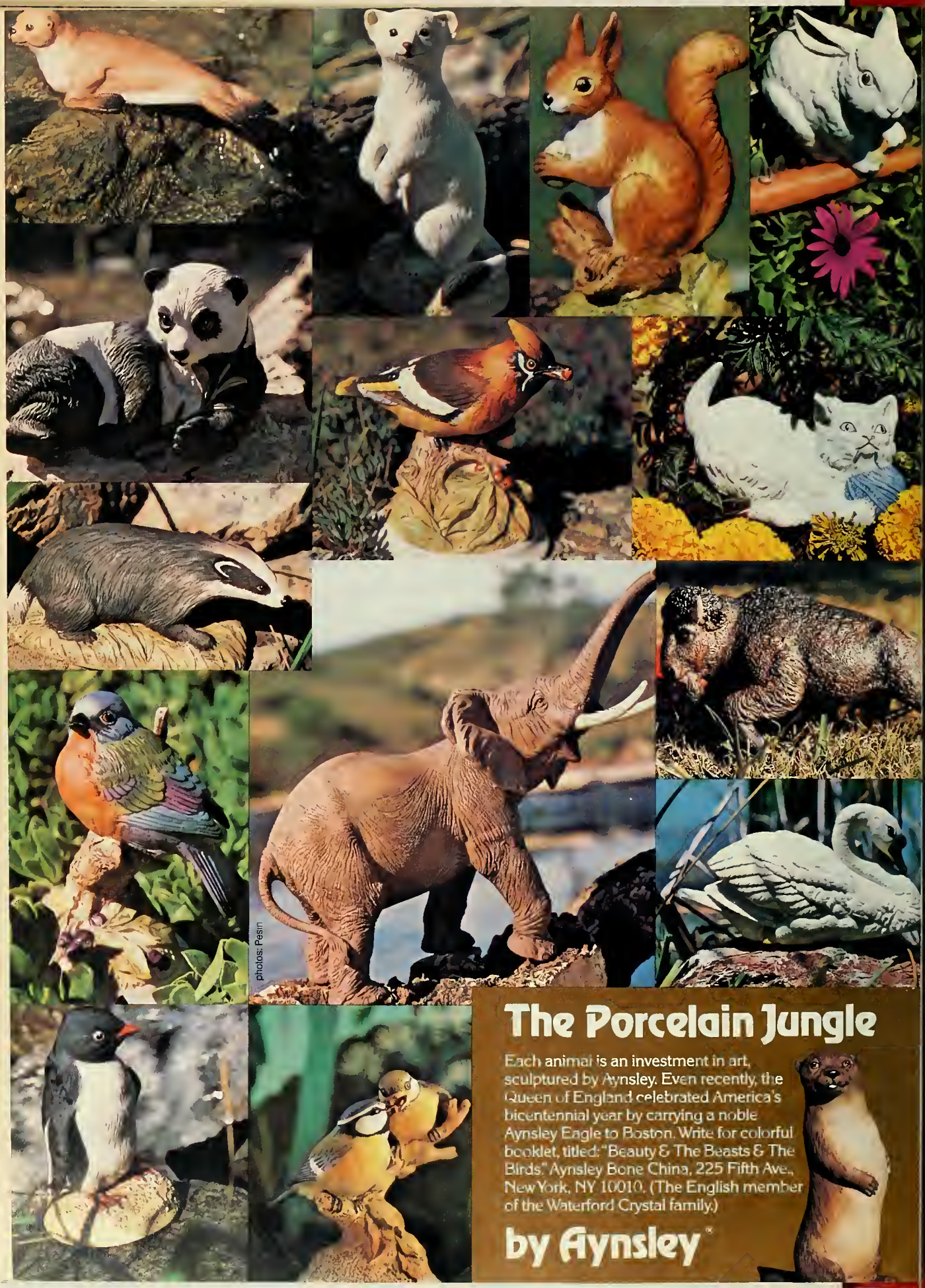


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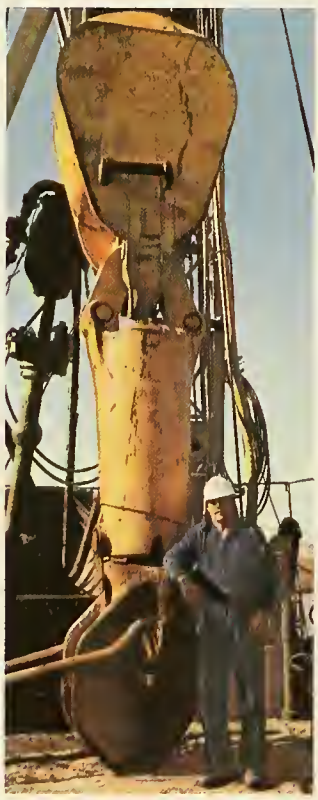
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NATURAL HISTORY

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April 1978

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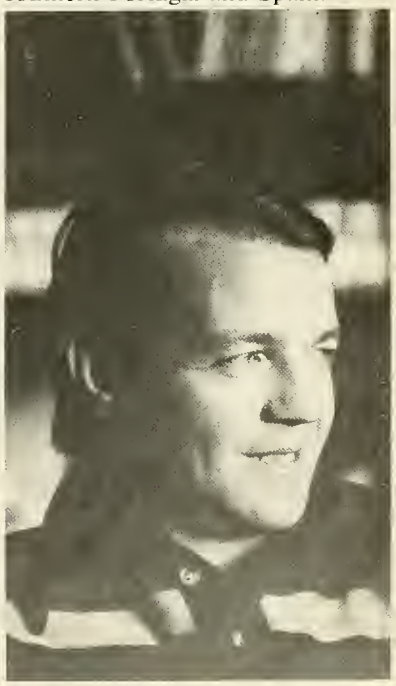
Doreen Buscemi, author of "The Last American Parakeet," has been an avid birder since the age of twelve. She has an impressive life-list to her credit, much of it compiled while hiking in the Everglades and the Appalachians, another favorite pastime. A free-lance writer and photographer, and a full-time housewife, her primary concern has been the rapid disappearance of Florida's wildlife. Her articles have appeared in *Family Health*, *Harper's*, and *Country Gentleman*.





The ecology, social behavior, and evolution of small mammals have been virtually a lifelong research pursuit for **Paul K. Anderson,** a professor of zoology at the University of Calgary. He writes that his doctoral thesis "dealt with the operation of evolutionary processes in island populations of salamanders. Salamanders reproduce only once a year and social interactions are less evident than in small mammals, which may reproduce repeatedly during an extended breeding season." This early revelation led Anderson to stalk the house mouse, a common and fecund rodent whose ecological and genetic population processes he has investigated on the western Canadian prairies, in the Rocky Mountains, and on Great Gull Island in Long Island Sound, New York.

"I have spent most of the research phase of my scholarly life in peasant villages, agricultural towns, and industrialized urban ghettos where rural countrymen have been drawn seeking jobs as unskilled labor," writes **David D. Gregory**. Between 1966 and 1968, he studied the effects of massive emigration in Andalusia. It was then that he first observed Holy Week in Seville. In addition, he traveled with Spanish villagers into the industrialized societies of Germany and Switzerland. In 1975 Gregory witnessed the reverse of this trend: Spanish workers being forced out of western Europe by an economic recession and returning home. This year, Gregory, assistant professor of anthropology at Dartmouth College, is studying the effects of migration on political organizations in southern Portugal and Spain.



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Willard K. Martin is a practicing architect, a member of the firm of Martin/Soderstrom/Matteson in Portland, Oregon. He also teaches graduate courses at the Washington State University School of Architecture. During travels to Central America, Hawaii, the Middle East, Greece, and Italy, Martin grew interested in "nature's solutions to problems of packaging and distributing seeds." He subsequently began to draw and make prints of methods of plant seed dispersal. A portfolio of his drawings, "Seeds: The Carriers of Life," appeared in the June–July 1973 issue of *Natural History*.



British-born **Stephen Sparks** is a NATO research fellow at the University of Rhode Island Graduate School of Oceanography. In 1973 while working on Santorini for his doctoral dissertation in geology, he was invited to join the international research team that was later to investigate Minoan ash recovered from the sea floor. Sparks is still examining the cores collected on that research cruise as well as studying volcanism in Iceland, the West Indies, Italy, and Greece. Something of a sports buff, his emigration to America has led him to switch his allegiance from the Yorkshire Cricket Club to the Boston Red Sox.

Coauthor **Haraldur Sigurdsson** was also a member of the Santorini research cruise team. He has done additional fieldwork on volcanology in Iceland and in the Lesser Antilles from Grenada in the south to Saba in the north. An Icelandic citizen, Sigurdsson is currently associate professor of oceanography at the University of Rhode Island.





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The Last American Parakeet

by Doreen Buscemi

In 1918, a Carolina parakeet died in the Cincinnati Zoo. Its remains have vanished, as has the species

Striking green and yellow parakeets were once found over much of the eastern United States. Today, only sixty years after their extinction, their existence is remembered mainly by ornithologists and bird lovers. Reams have been written about the passenger pigeon, the ivory-billed woodpecker, and other extinct and vanishing birds, but the last Carolina parakeet was not even accorded a place of honor in a museum. It died at the Cincinnati Zoological Gardens in 1918, four years after the last passenger pigeon died there. The passenger pigeon was sent to the Smithsonian Institution where it is on display today, but no one knows what happened to the skin of the last parakeet.

Even while they lived, the birds were not studied closely. No trained ornithologist ever saw a nest and most of the information we have regarding their breeding and nesting habits has come from the observation of captive birds.

A wedge-tailed bird slightly larger than a mourning dove, the Carolina parakeet was the only native representative of the parrot family to breed within the United States in recent times. The bird's body was a bright green; its head lemon yellow with an orange forehead. The species was divided into two geographic races: *Conuropsis carolinensis carolinensis* and *C. c. ludoviciana*. The first was found mainly in the southeastern United States from Florida north to Virginia and west to Alabama; occasionally it ranged north to eastern Pennsylvania and New York. The second subspecies ranged from Mississippi and Louisiana north to Indiana and Ohio and west to the foothills of the Rocky Mountains.

Parrots are usually tropical birds but the Carolina parakeet was an obvious exception. Ornithologist Alexander Wilson saw them "in the



AMNH

month of February along the banks of the Ohio, in a snowstorm." A flock of these hardy birds once appeared in midwinter at Albany, New York. They were frequently sighted in the north when snow covered the ground and other species had migrated.

Although not migratory, Carolina parakeets traveled widely in search of food. Compact flocks numbering hundreds of birds could dart in and out of the densest timber with ease. The flocks were beautiful in flight since the birds flew with inclinations of the body that displayed the brilliant greens and yellows of their plumage. While on the wing, Carolina parakeets kept up a constant chatter; one observer noted that their shrill cries could be heard for miles.

"On reaching a spot which affords a supply of food," Audubon wrote in his *Ornithological Biography,* "instead of alighting at once, as many other birds do, the parakeets take a good survey of the neighborhood, passing over it in circles of great extent, first above the trees, and then gradually lowering until they almost touch the ground, then suddenly reascending, they all settle on the tree that bears the fruit of which they are in quest, or in one close to the field in which they expect to regale themselves."

The original food of the Carolina parakeet, before the United States was widely settled, consisted almost entirely of seeds, primarily those of cocklebur or thistle, but also those of various trees, most commonly of cypress, sycamore, and maple. Wild grapes, berries, nuts, buds, and flowers rounded out their diet. The birds were seldom far from the type of habitat—heavily wooded banks of rivers and streams or an extensive cypress swamp—that supported an abundance of these foods.

Early morning hours would find the parakeets out feeding. They re-

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tired to the deep woods during the hottest part of the day and then returned to the forest edge and nearby fields to forage in the late afternoon. An entire flock would sometimes roost for the night in a large, hollow tree, the birds hanging by their powerful beaks and claws.

Clumsy and slow on the ground, Carolina parakeets were acrobats in the trees. Using its beak, a parakeet could swing through the trees, moving about on branches that looked too slight to support it. This ability enabled the parakeet to reach almost any seed on a tree.

Carolina parakeets are thought to have nested colonially in hollow trees—probably oak, cypress, or sycamore. There were also reports of large colonies building nests of sticks. The birds may have done both. When hollow trees were not present in sufficient numbers to accommodate a colony, the birds may have built their nests in the branches of trees.

The close-grained eggs of the Carolina parakeet were glossy white and deeply pitted. There are two egg dates from the wild—both from Florida in the month of April. The number of eggs in a normal clutch—while not known for certain—is believed to have been two or three. In captivity, the birds were careless in the care and feeding of their young. As for the development and care of the young in the wild, there are no accurate records. The Carolina parakeet was exterminated before it was ever really known.

The extinction of the Carolina parakeet can be attributed to a variety of causes. For one thing, the birds had some commercial value; many were shot for the millinery trade. In the 1800s fashionable women not only wore feathers on their hats, they often wore an entire stuffed bird. The colorful parakeets were ideal for this purpose. Professional hunters also captured large numbers of parakeets and sold them as cage birds. The birds were edible and many early writers reported that the flesh was very tasty. Unlike passenger pigeons, the Carolina parakeet was never shot for the commercial food market, but they were commonly utilized as food by many settlers and farmers.

Farmers considered the Carolina parakeet a destructive pest. If the birds had continued to eat wild seeds and fruit, as they did before the country was settled, they might not have been exterminated. But they developed a fondness for cultivated crops and fruits. Large flocks of parakeets would settle on a wheat field and eat much of the crop or they would fly into an orchard and strip the fruit off the trees. Little was safe from the birds—in Florida, they even developed a taste for oranges and bananas. Sometimes they didn't eat the seeds and fruit but only damaged the crop by snapping off the heads of wheat stalks or taking one bite out of a piece of fruit. Under the circumstances, one can understand why farmers wanted to get rid of the birds.

Perhaps the worst habit of the Carolina parakeet, at least in terms of its survival, was its concern for wounded members of the flock. The cries of an injured bird would bring the entire flock back to hover over the crippled individual. This brought the birds back into shooting range and an entire flock was often decimated in this manner. In *The Birds of Eastern North America*, C.J. Maynard wrote that he frequently saw "every individual in a flock killed one after the other, and the last bird betrayed as much anxiety for the fate of its prostrate friends . . . as it did when the first fell."

There were probably other, less tangible reasons for the extinction of the parakeets. The late Frank Chapman, curator of birds at the American Museum of Natural History, believed that the parakeets were "not equipped to withstand contact with civilization."

Whatever the reasons, their numbers began to decline in the early nineteenth century. As early as 1832, Audubon reported that "our parakeets are very rapidly diminishing in number; and in some districts, where twenty-five years ago they were plentiful, scarcely any are now to be seen."

From that time on, the range of the Carolina parakeet gradually contracted. By the 1860s, the birds were still fairly common throughout the Gulf Coast States and the Mississippi and Arkansas River valleys, although they were gone from the rest of their range. The parakeet was restricted to Florida by the 1890s, with a few scattered reports of the birds in Kansas and Missouri. In isolated sections of southern Florida, the species hung on for another decade. There, Chapman saw the last wild flock near Taylor Creek, northeast of Lake Okeechobee, in April 1904. There were thirteen birds in the flock, and Chapman shot four.

This was the last authenticated sighting of the Carolina parakeet and the official date for the extinction of the species in the wild. Several birds lived on in captivity but the last of these died at the Cincinnati Zoo.

For many years, there were reports of the Carolina parakeet being sighted, but none were ever verified. There is a possibility, however, that isolated flocks survived after 1904 in some of the impenetrable swamps of the Deep South. Perhaps the most intriguing of these reports surfaced in the 1930s in South Carolina, where George M. Melamphy was working on a wild turkey project in the vast Santee Swamp. While in his turkey blind, he reportedly sighted Carolina parakeets and ivory-billed woodpeckers on numerous occasions. He contacted Alexander Sprunt, Jr., of the National Audubon Society who, along with Robert P. Allen, undertook an investigation in late 1936. Because the expedition was plagued by cloudy weather, rain, and mist, the investigators never had good light for observation. They did, however, see a flight line of birds that appeared to be Carolina parakeets. On another occasion, Sprunt caught sight of a green bird he believed was a parakeet.

Unfortunately, the existence of parakeets in the Santee Swamp was never verified even though the presence of the ivory-bill was definitely confirmed. Years later, Allen doubted that parakeets were in the swamp, but Sprunt disagreed. It was his "firm and considerable belief that the Carolina parakeet was in the Santee Swamp in 1936, a remnant of a population which probably had always lived there."

We will never know for certain since shortly after the expedition, the Santee Swamp disappeared beneath the Santee-Cooper Hydroelectric Project. That great river swamp, like the Carolina parakeet, is now gone forever. □

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Bathybius Meets Eozoon

Early evolutionists thought these imaginary creatures must exist, so they found them

When Thomas Henry Huxley lost his young son, "our delight and our joy," to scarlet fever, Charles Kingsley tried to console him with a long peroration on the soul's immortality. Huxley, who invented the word "agnostic" to describe his own feelings, thanked Kingsley for his concern, but rejected the proferred comfort for want of evidence. In a famous passage, since taken by many scientists as a motto for proper action, he wrote: "My business is to teach my aspirations to conform themselves to fact, not to try and make facts harmonize with my aspirations. . . . Sit down before fact as a little child, be prepared to give up every preconceived notion, follow humbly wherever and to whatever abysses nature leads, or you shall learn nothing." Huxley's sentiments were noble, his grief affecting. But Huxley did not follow his own dictum, and no creative scientist ever has.

Great thinkers are never passive before facts. They ask questions of nature; they do not follow her humbly. They have hopes and hunches, and they try hard to construct the world in their light. Hence, great thinkers also make great errors.

Biologists have inspired a long and special chapter in the catalog of major mistakes—imaginary animals that should exist in theory. Voltaire spoke truly when he quipped: "If God did not exist, it would be necessary to invent him." Two related and intersecting chimeras arose during the early days of evolutionary theory—two animals that should have been, by Darwin's criteria, but were not. One of them had Thomas Henry Huxley for a godfather.

For most creationists, the gap between living and nonliving posed no special problem. God had simply made the living, fully distinct and more advanced than the rocks and chemicals. Evolutionists sought to close all the gaps. Ernst Haeckel, Darwin's chief defender in Germany and surely the most speculative and imaginative of early evolutionists, constructed hypothetical organisms to span all the spaces. The lowly amoeba could not serve as a model of the earliest life, for its internal differentiation into nucleus and cytoplasm indicated a large advance from primal formlessness. Thus Haeckel proposed a lowlier organism composed only of unorganized protoplasm, the Monera. (In a way, he was right. We use his name today for the kingdom of bacteria and blue-green algae, organisms without nucleus or mitochondria—although scarcely formless in Haeckel's sense.)

Haeckel defined his moneran as "an entirely homogeneous and structureless substance, a living particle of albumin, capable of nourishment and reproduction." He proposed a moneran as an intermediate form between the nonliving and living. He hoped that it would solve the vexing question of life's origin from the inorganic, for no problem seemed thornier for evolutionists and no issue attracted more rear-guard support for creationism than the apparent gap between the most complex chemicals and the simplest organisms. Haeckel wrote: "Every true cell already shows a division into two different parts, i.e., nucleus and plasm. The immediate production of such an object from spontaneous generation is obviously only conceivable with difficulty; but it is much easier to conceive of the production of an entirely homogeneous, organic substance, such as the structureless albumin body of the Monera."

During the 1860s, the identification of monerans assumed high priority on the agenda of Darwin's champions. And the more structureless and diffuse the moneran, the better. Huxley had told Kingsley that he would follow facts into a metaphorical abyss. But when he examined a true abyss in 1868, his prior hopes and expectations guided his observations. He studied some mud samples dredged from the sea bottom northwest of Ireland ten years before. He observed an inchoate, gelatinous substance in the samples. Embedded in it were tiny, circular, calcareous plates called coccoliths. Huxley identified his jelly as the heralded, formless moneran and the coccoliths as its primordial skeleton. (We now know that coccoliths are fragments of algal skeletons, which sink to the ocean bottom following the death of their planktonic producers.) Honoring Haeckel's prediction, he named it *Bathybius*

by Stephen Jay Gould

Haeckelii. "I hope that you will not be ashamed of your godchild," he wrote to Haeckel. Haeckel replied that he was "very proud," and ended his note with a rallying cry: "Viva Monera."

Since nothing is quite so convincing as an anticipated discovery, *Bathybius* began to crop up everywhere. Sir Charles Wyville Thompson dredged a sample from the depths of the Atlantic and wrote: "The mud was actually alive; it stuck together in lumps, as if there were white of egg mixed with it; and the glairy mass proved, under the microscope, to be a living sarcode. Prof. Huxley . . . calls it *Bathybius*." (The Sarcodina are a group of single-celled protozoans.) Haeckel, following his usual penchant, soon generalized and imagined that the entire ocean floor (below 5,000 feet) lay covered with a pulsating film of living *Bathybius*, the *Urschleim* (original slime) of the romantic nature philosophers (Goethe was one) idolized by Haeckel during his youth. Huxley, departing from his usual sobriety, delivered a speech in 1870 and proclaimed: "The *Bathybius* formed a living scum of film on the seabed, extending over thousands upon thousands of square miles . . . it probably forms one continuous scum of living matter girding the whole surface of the earth."

Having reached its limits of extension in space, *Bathybius* oozed out to conquer the only realm left—time. And here it met our second chimera. A tale writ larger than life, tailor-made for Hollywood as "*Bathybius* meets *Eozoon*."

Fermentation: The miracle that turns the juice of the grape into wine.



Although it is an oft-proclaimed truth that fine wine is a living growing thing, nowhere is this more evident than during that critical, and still somewhat mysterious, process called fermentation.

Yeast: The Catalyst

It is possible that a quantity of fine grapes crushed and left to themselves in an open container will, in time, ferment and yield an acceptable wine.

It is probable, however, that these same grapes will yield a wine not so pleasant.

Which it will become depends on the vagaries of simple, one-celled plants called yeasts which are found naturally in the bloom on the skins of grapes.

A Louis Pasteur Discovery

Until 1864, wine-making was a matter of uncertainty. But then Louis Pasteur discovered that these yeasts were, indeed, the agents that caused fermentation.

Equally important, he discovered that specific strains with desirable characteristics could be isolated and substituted for the wild yeast in the wine-making process, a major step toward predictable excellence.

Today, our winemakers are devoted to the study of yeasts and to their improvement. Because no one yeast works equally well in every case, we are constantly striving to isolate the ideal yeast for the different varieties of wines.

This development of the specific yeast which maximizes a grape's natural flavor potential is a primary study we have pursued for years.

To achieve a wine of predictable excellence year after year, we developed the first successful dehydration of pure wine yeast. The dehydrated form maintains the consistent purity from year to year and provides us with a "cleaner" wine that is truer in flavor and fragrance to the grape.

Some Like It Cold

During fermentation, heat is created. If we permit the fermenting juice or "must" to attain a temperature of only ninety degrees, the yeast can be injured. At one-hundred degrees, most yeast will die.

Over the years, we have developed precise cooling methods for keeping the fermenting liquid at the optimum lower temperature. This varies from grape to grape. For example, the Sauvignon Blanc, French Colombard, Chenin Blanc, Riesling or Chardonnay we use for our white wines are far more delicate and sensitive to temperature than their more robust red cousins.

We determined that fermenting them at a cooler temperature slows the change from juice to wine and protects the delicacy of the resultant wine.

In this cooled state, the juice can ferment as long as fourteen days rather than three or four.

The Test Fermentation

Knowing the precise moment to draw the wine is a combination of the skill and art of our winemakers.

In some cases we actually take grape samples a few days before harvest and, on a small scale, proceed with fermentation. This gives us a preview of what to expect, and, we then make whatever adjustments necessary to produce the most consistently excellent wine.

The Reason For All This Care

It is only by utilizing all the skills gained in many years of work and study that we can achieve our intent: to bring you the finest wines that we, or anyone else, can provide.

Ernest & Julio Gallo, Modesto, California

Eozoon canadense, the dawn animal of Canada, was another organism whose time had come. The fossil record had caused Darwin more grief than joy. He balked particularly at the Cambrian explosion, the coincident appearance of almost all complex organic designs, not near the beginning of the earth's history, but more than five-sixths of the way through it (see my columns of November 1974 and August/September 1976). His opponents took this explosion as the moment of creation, for not a single trace of Precambrian life had been discovered when Darwin wrote the *Origin of Species*. (We now have an extensive record of monerans from these early rocks, see my column of February 1977.) Nothing could have been more welcome than a Precambrian organism, the simpler and more formless the better.

In 1858 a collector for the Geological Survey of Canada found some curious specimens among the world's oldest rocks. They were made of thin, concentric layers, alternating between serpentine (a silicate) and calcium carbonate. Sir William Logan, director of the Survey, thought that they might be fossils and displayed them to various scientists, receiving in return little encouragement for his views.

Logan found some better specimens near Ottawa in 1864, and brought them to Canada's leading paleontologist, J. William Dawson, the principal of McGill University. Dawson found "organic" structures in his microscope slides, most notably a canal system in the calcite, and identified the concentric layering as the skeleton of a giant foraminifer, more diffusely formed but hundreds of times larger than any modern relative. He named it *Eozoon canadense*.

Darwin was delighted. *Eozoon* entered the fourth edition of the *Origin of Species* with Darwin's firm blessing: "It is impossible to feel any doubt regarding its organic nature." (Ironically, Dawson himself was a staunch creationist, probably the last prominent holdout against the Darwinian tide. As late as 1897, he wrote *Relics of Primeval Life*, a book about *Eozoon*. In it he argues that the persistence of simple Foraminifera throughout geologic time disproves natural selection since any struggle for existence would replace such lowly creatures with something more exalted.)

Bathybius and *Eozoon* were destined for union. They shared the desired property of diffuse formlessness and differed only in *Eozoon*'s discrete skeleton. Either *Eozoon* had lost its shell to become *Bathybius* or the two primordial forms were closely related as exemplars of organic simplicity. The great physiologist W. B. Carpenter, a champion of both creatures, wrote:

> If *Bathybius* . . . could form for itself a shelly envelope, that envelope would closely resemble *Eozoon*. Further, as Prof. Huxley has proved the existence of *Bathybius* through a great range not merely of depth but of temperature, I cannot but think it probable that it has existed continuously in the deep seas of all geological epochs. . . . I am fully prepared to believe that *Eozoon*, as well as *Bathybius*, may have maintained its existence through the whole duration of geological time.

A vision to titillate any evolutionist. The anticipated, formless organic matter had been found, and it extended throughout time and space to cover the floor of the mysterious and primal ocean bottom.

Before I chronicle the downfall of both creatures, I want to identify a bias that lay unstated and undefended in all the primary literature. All of the participants in the debate accepted without question the "obvious" truth that the most primitive life would be homogeneous and formless, diffuse and inchoate.

Carpenter wrote that *Bathybius* was "a type even lower, *because less definite*, than that of Sponges." Haeckel declared that "protoplasm exists here in its simplest and earliest form, i.e., it has scarcely any definite form, and is scarcely individualized." Huxley proclaimed that life without the internal complexity of a nucleus proved that organization arose from indefinite vitality, not vice versa: *Bathybius* "proves the absence of any mysterious power in nuclei, and shows that life is a property of the molecules of living matter, and that organization is the result of life, not life the result of organization."

But why, when we think about it, should we equate formless with primitive? Modern organisms encourage no such view. Viruses are scarcely matched for regularity and repetition of form. The simplest bacteria have definite shapes. The taxonomic group that houses the amoeba, that prototype of slithering disorganization, also accommodates the Radiolaria, the most beautiful and most complexly sculpted of all regular organisms. DNA is a miracle of organization; Watson and Crick elucidated its structure by building an accurate Tinkertoy model and making sure that all the pieces fit. I would not assert any mystical Pythagorean notion that regular form underlies all organization, but I would argue that the equation of primitive with formless has roots in the outdated progressivist metaphor that views organic history as a ladder leading inexorably through all the stages of complexity from nothingness to our own noble form. Good for the ego to be sure, but not a very good outline of our world.

In any case, neither *Bathybius* nor *Eozoon* outlived Queen Victoria. The same Sir Charles Wyville Thompson who had spoken so glowingly of *Bathybius* as a "glairy mass . . . actually alive" later became chief scientist of the *Challenger* expedition during the 1870s, the most famous of all scientific voyages to explore the world's oceans. The *Challenger* scientists tried again and again to find *Bathybius* in fresh samples of deep-sea mud, but with no success.

When mud samples were stored for later analysis, scientists traditionally added alcohol to preserve organic material. Huxley's original specimens of *Bathybius* had come from samples stored with alcohol for more than a decade. One member of the *Challenger* expedition noticed that *Bathybius* appeared whenever he added alcohol to a fresh sample. The expedition's chemist then analyzed *Bathybius* and found it to be no more than a colloidal precipitate of calcium sulfate, a product of the reaction of mud with alcohol. Thompson wrote to Huxley, and Huxley—without complaining—ate crow (or ate leeks, as he put it). Haeckel, as expected, proved more stubborn, but *Bathybius* quietly faded away.

Eozoon hung on longer. Dawson defended it literally to the death in some of the most acerbic comments

Please turn to page 22

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On Photographing the Invisible

To the naked eye, it was a Swedish 80-ore postage stamp. A rarity, and very valuable.

The camera, however, told quite another story. The stamp was a counterfeit.

Faint traces of tampering that were hidden to the naked eye were revealed by the camera. Someone, somewhere, had ingeniously altered the stamp by chemically removing a surprint. The stamp was worthless.



To the naked eye (left), the stamp was genuine. To the camera (right), it was a counterfeit. Note the faint, dark traces of tampering now revealed in the upper section.

What manner of exotic camera was this that could "see" the invisible?

The lens: one of the 20 in the Hasselblad arsenal, the 105mm Zeiss UV-Sonnar f4.3. Designed for photography within the ultraviolet portion of the electromagnetic spectrum, its costly quartz elements can detect radiations that are unseeable by the human eye.

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The camera: an otherwise perfectly standard Hasselblad 500C/M, normally fitted with an 80mm Zeiss Planar f2.8 multi-coated lens.

This is the basic model that allows you to tap into the vast Hasselblad System. It is one of the most bewilderingly versatile cameras the world has ever known. Yet so marvelously simple to operate that it often plays the part of the family snapshot camera.

A True System.

The Hasselblad System is a prodigious array of 4 cameras, 20 lenses, 8 viewfinders, 9 film magazines, and over 300 other accessories. Choose the right pieces, and your 500C/M would be equipped for sports, aerial, architectural, and fashion photography.

And portrait, landscape, medical, underwater, and news photography.

And wildlife, laboratory, industrial, and child photography.

And you would always have the right film in the camera at the right time. You can shift from color to black-and-white and back again to color—and resume shooting at precisely the right frame—by popping in the protective dark slide and switching film backs.

The Camera with Nine Backs.

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You begin to realize why eight out of ten top commercial photographers surveyed name Hasselblad as the medium-format camera used in their work.

Retained Value vs. Obsolescence.

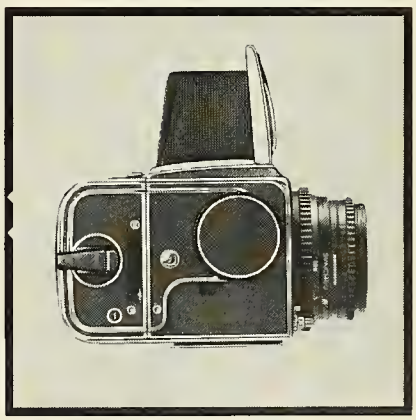
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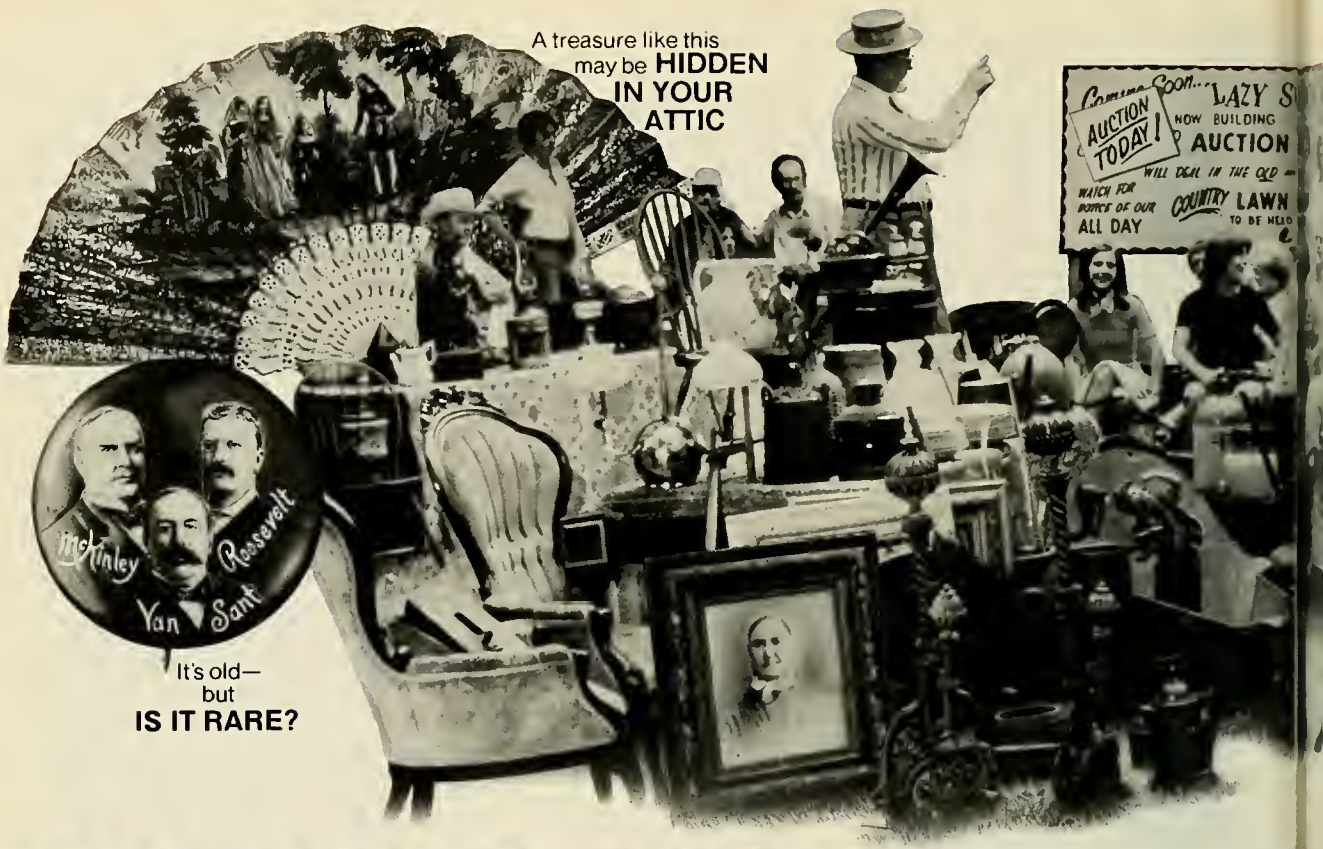
Little wonder, then, that a preowned Hasselblad commands such a high price...if its owner can be persuaded to part with it at all.

HASSELBLAD



The Hasselblad 500C/M.

A lavish brochure is available free if you write: Braun North America, Dept NH4H, 55 Cambridge Parkway, Cambridge, Mass. 02142. Braun North America is a division of The Gillette Company and exclusive marketer of Hasselblad cameras in the U.S.



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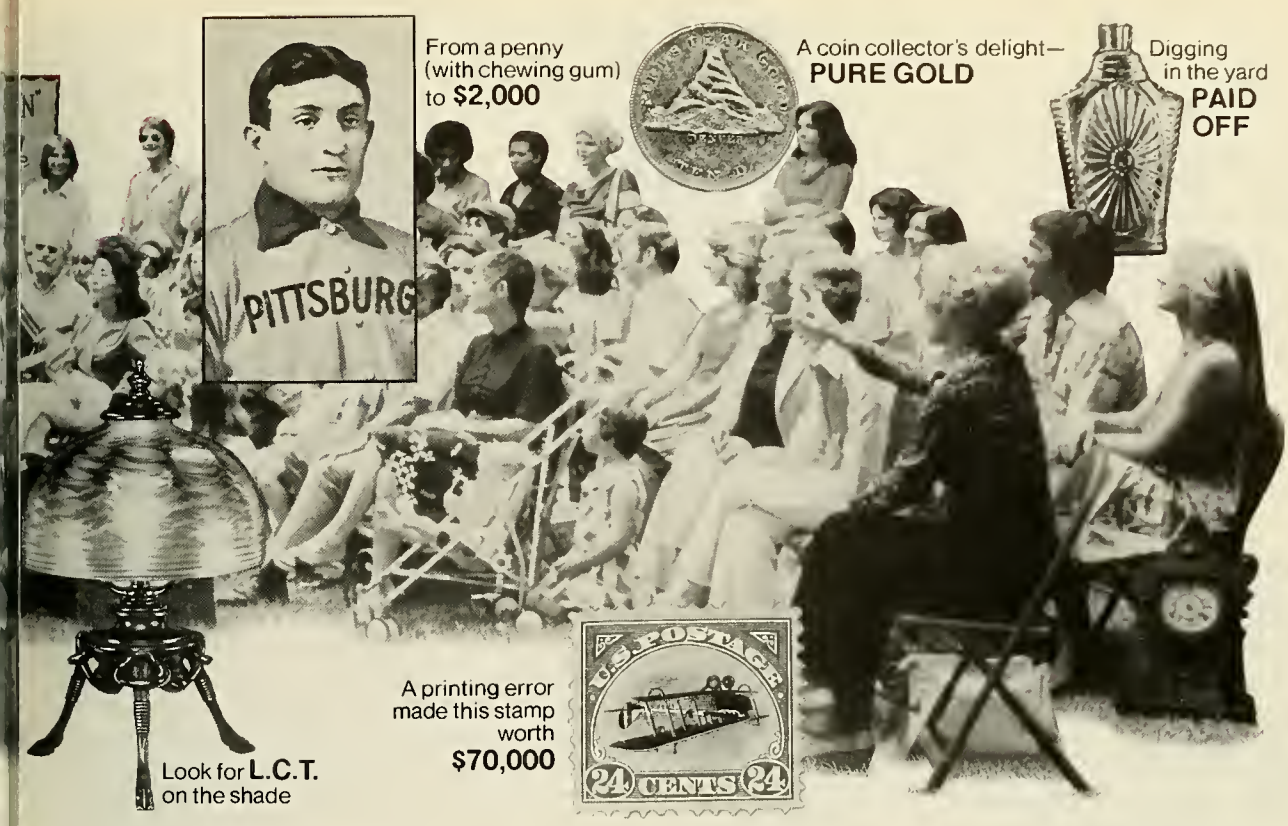
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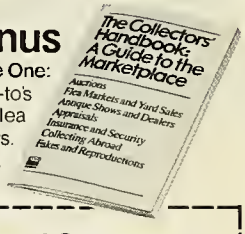
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ever written by a scientist. Of one German critic, he remarked in 1897: "Mobius, I have no doubt, did his best from his special and limited point of view; but it was a crime which science should not readily pardon or forget, on the part of editors of the German periodical, to publish and illustrate as scientific material a paper which was so very far from being either fair or adequate." Dawson, by that time, was a lone holdout (although Kirkpatrick of last month's column revived *Eozoon* in a more bizarre form later). All scientists had agreed that *Eozoon* was a metamorphic product of heat and pressure. Indeed, it had only been found in highly metamorphosed rock, a singularly inauspicious place to find a fossil. If any more proof had been needed, the discovery of *Eozoon* in blocks of limestone ejected from Mount Vesuvius settled the issue in 1894.

Bathybius and *Eozoon*, ever since, have been treated by scientists as an embarrassment best forgotten. The conspiracy succeeded admirably, and I would be surprised if one percent of modern biologists ever heard of the two fantasies. Historians, trained in the older (and invalidated) tradition of science as a march to truth mediated by the successive shucking of error, also kept their peace. What can we get from errors except a good laugh or a compendium of moral homilies framed as "don'ts."

Modern historians of science have more respect for such inspired errors. They made sense in their own time; that they don't in ours is irrelevant. Ours is no standard for all ages; science is always an interaction of prevailing culture, individual eccentricity, and empirical constraint. Hence, *Bathybius* and *Eozoon* have received more attention in the 1970s than in all previous years since their downfall. (In writing this column, I was guided to original sources and greatly enlightened by articles of C. F. O'Brien [*Isis*, 1971] on *Eozoon*, and N. A. Rupke [*Studies in the History and Philosophy of Science*, 1976], and P. F. Rehbock [*Isis*, 1975] on *Bathybius*. The article by Rehbock is particularly thorough and insightful. *Isis* is the leading professional journal in the history of science.)

Science contains few outright fools. Errors usually have their good reasons once we penetrate their context properly, rather than judge them according to our current perception of "truth." They are usually more enlightening than embarrassing, for they are signs of changing contexts. The best thinkers have the imagination to create organizing visions, and they are sufficiently adventurous (or egotistical) to float them in a complex world that can never answer "yes" in all detail. The message provided by a study of inspired error is not a homily about the sin of pride, but a recognition that the capacity for great insight and great error are opposite sides of the same coin—and that the currency of both is brilliance.

Bathybius was surely an inspired error. It served the larger truth of advancing evolutionary theory. It provided a captivating vision of primordial life, extended throughout time and space. As Rehbock argues, it filled a plethora of functions as, simultaneously, lowliest form of protozoology, elemental unit of cytology, evolutionary precursor of all organisms, first organic form in the fossil record, major constituent of modern marine sediments (in its coccoliths), and source of food for higher life in the nutritionally impoverished deep oceans. When *Bathybius* faded away, the problems that it had defined did not disappear. *Bathybius* inspired a great amount of fruitful scientific work and served as a focus for defining important problems still with us.

Orthodoxy can be as stubborn in science as in religion. I do not know how to shake it except by vigorous imagination that inspires unconventional work and contains within itself an elevated potential for inspired error. As the great Italian economist Vilfredo Pareto wrote: "Give me a fruitful error any time, full of seeds, bursting with its own corrections. You can keep your sterile truth for yourself." Not to mention a man named Thomas Henry Huxley who, when not in the throes of grief or the wars of parson hunting, argued that "irrationally held truths may be more harmful than reasoned errors."

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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This year, the Grand Prize of *Natural History*'s photographic competition will be two tickets for the American Museum of Natural History's Discovery Tour of Egypt. The three-week trip will include a two-day stop in London, followed by a leisurely cruise on the Nile from Cairo to Aswan, with an optional flight to Abu-Simbel.

Besides the Grand Prize, the 1978 competition offers cash prizes totaling more than $3,000. The winning entries will be published in a special double issue of *Natural History* in August and will be exhibited at the American Museum of Natural History.

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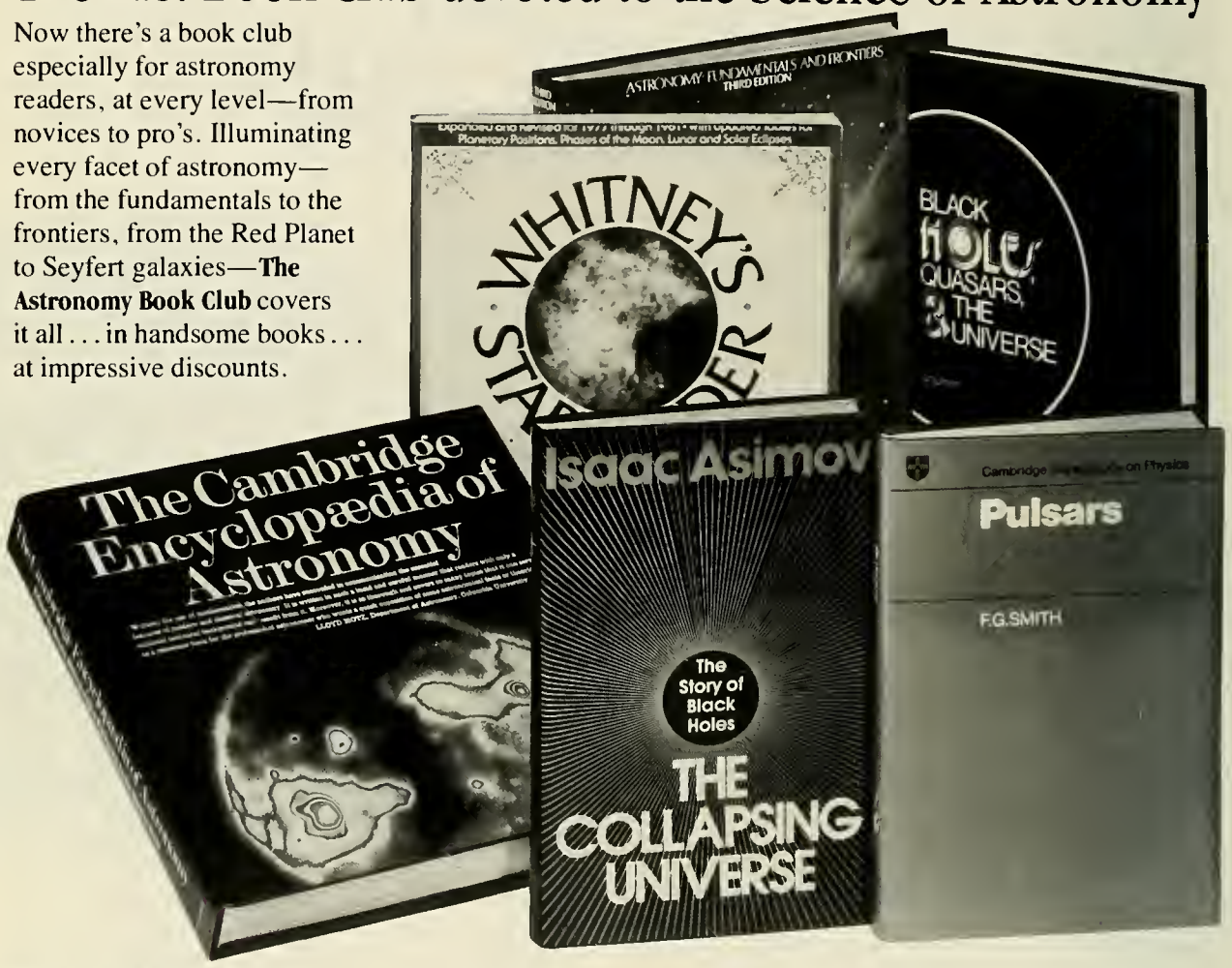
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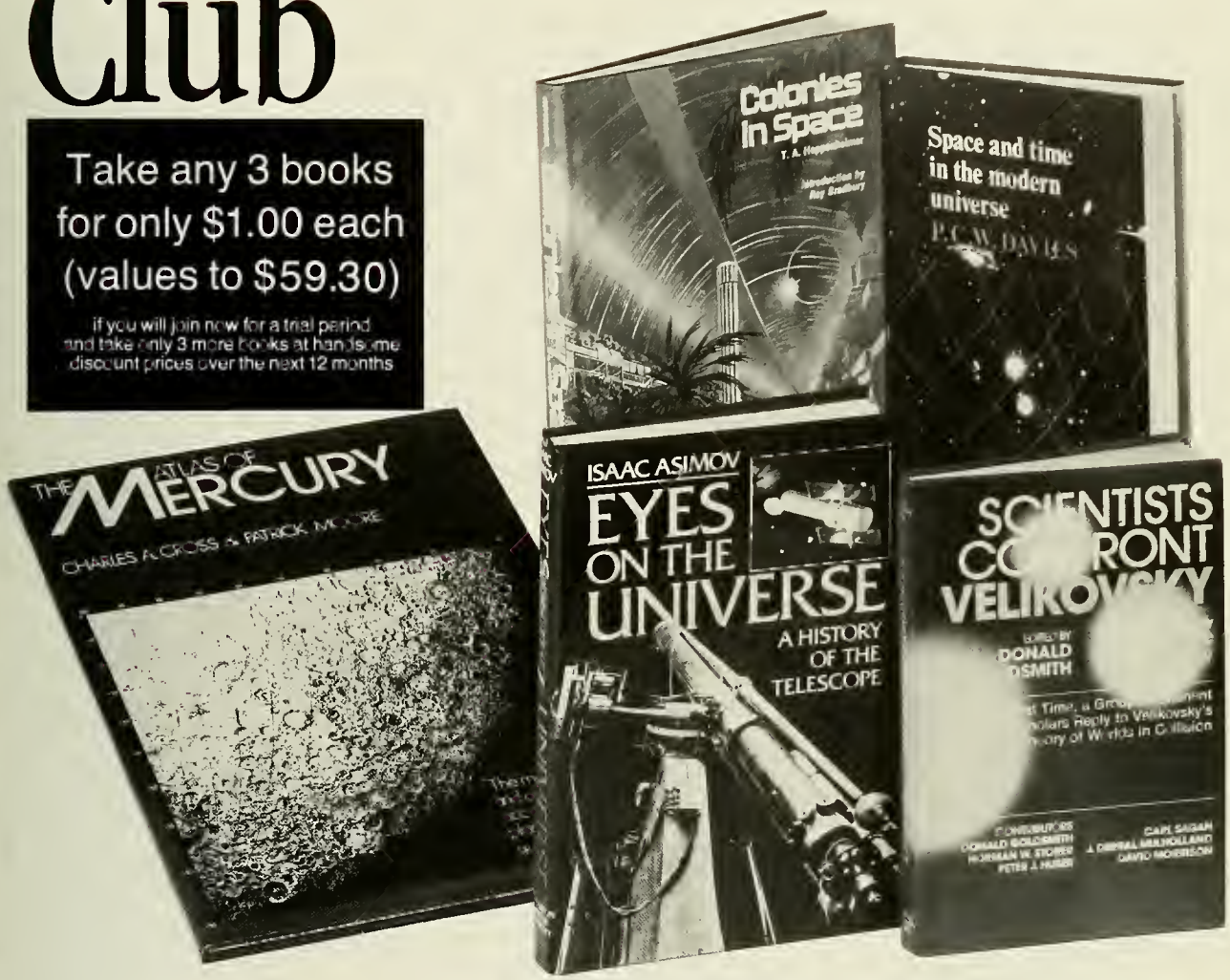
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Blackouts and Births

by Janos Balog

April marks the ninth month after New York City's 1977 blackout. Can we expect a baby boom?

April 1978 is the ninth month following the blackout that began in New York City during the evening of July 14, 1977. In early August 1966, nine months after the blackout that began on November 9, 1965, and lasted up to ten hours, New York City supposedly experienced a "baby boom," a 30 percent increase in live births. Can we expect a similar boom in births this month? I think such an expectation is unrealistic because it is based on the assumption that when people are confronted by a dramatic historical or natural event that curtails their usual activities, copulation increases, resulting in a higher birth rate nine months later. (Birth occurs 270 days after the mother's last ovulation or 282 days from her last menstrual period.) Even if increased coitus does take place, it does not necessarily result in a higher birth rate.

On August 10, 1966 (270 days after the 1965 blackout), the front page of the *New York Times* announced that six hospitals in New York City had reported "a sharp increase" in births. At some hospitals, the baby boom continued for as long as a week. Various social scientists and doctors were asked to explain the phenomenon, and one sociologist opined, "The lights went out and people were left to interact with each other."

In a follow-up article on August 11, the *Times* reported that embracing couples had been found preserved in the ashes of Pompeii, then quoted a new father who had been in New York during the 1965 blackout: "Everyone needed to be reassured." Births were reported normal in suburban New York, many of whose commuters had been stranded in the city.

This story said that according to the National Office of Vital Statistics, fertility rates rose sharply nine months after such national and international crises as Pearl Harbor and the outbreak of the Korean War. The relevance of this finding seems unclear because the agency also said that births had dropped nine months after President Kennedy's assassination.

In 1970, statistician J. Richard Udry, using New York City Department of Health figures, tried to debunk the so-called baby boom. He reasoned that if an unusually large number of conceptions had taken place on November 10, 1965, almost all of the resultant births would have occurred between June 27 and August 14, 1966. Therefore, that period would include a greater percentage of the year's births than the same period in other years.

But as Udry checked births between June 27 and August 14 in the five years preceding 1966, he found that 1966 had not been unusual. From 1961 through 1966, August births consistently constituted between 13.9 and 14.1 percent of the total annual number of live births.

On August 10, 1966, there were 455 live births, which was not particularly unusual for the month, during which daily births ranged from a low of 344 to a high of 508. Udry concluded that the New York baby boom of 1966 was a fallacy but that statistical analysis is too bloodless to defeat the pleasing fantasy that "when people are trapped by some immobilizing event . . . most will turn to copulation." He noted that nine months after the massive snowfall in Chicago in the winter of 1967, local hospitals were prepared for "an avalanche of 'snow babies' " that never materialized.

We can add to Udry's figures the possibility that on August 10, 1966, more births occurred at some New York hospitals because of unknown factors that brought to term an increased number of conceptions from dates other than November 10, 1965. We know little about the mechanism that triggers labor, and besides, there is no real reason why a blackout, even if associated with increased coitus, should lead to significantly more conception, unless, as one doctor facetiously suggested, people had trouble finding their contraceptives in the dark.

We do know that sperm normally lives for about three days, and if we go by Kinsey's finding that the average married couple engages in coitus 2 to 2.5 times a week, we can assume that under normal marital conditions, the female genital tract is reasonably well saturated with sperm throughout the month, well prepared for the ovum whenever ovulation may occur. Chances are that an increase in coitus on a given day, even in a city of about 7½ million people, would not substantially increase the conception rate.

But there was an increase in the birth rate in 1942, nine months after Pearl Harbor (December 7, 1941), and this is often cited as proof that increased coitus does boost births. However, we must take into account the atmosphere of national emergency that prevailed at the time of Pearl Harbor. Young people who, complying with forties morals, had previously avoided premarital affairs, may have engaged in coitus because they anticipated the draft and almost immediate separation. This

New York City, July 14, 1977; Eric Meola, Contact





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sort of doomsday coitus among one segment of the population could have contributed significantly to the higher birth rate nine months later. I doubt that there was an increased incidence of conception among Americans who were already cohabiting.

To understand why frequency of coitus and a high birth rate are not necessarily related, we must consider the physiology of procreation in human beings. By the early part of the nineteenth century, scientists had already determined that in order to conceive, a woman must first ovulate. But only relatively recently, in 1930, was the timing of ovulation established—midway through a woman's menstrual cycle or fourteen days before her next period. Given that most women ovulate regularly once a month, on a day that has nothing to do with the day or days of coitus, then on any day of the month, only one woman in twenty-eight is ovulating. In this case, a higher birth rate after dramatic events is difficult to accept.

If the birth rate increases significantly on a specific day, however, we must make two assumptions: ovulation must have occurred in addition to normal, midcycle ovulation, and this paracyclic ovulation must have coincided with coitus. There are, in fact, many incidents of conception that do seem to have occurred outside of midcycle ovulation. The best known example is the high failure rate of the rhythm method. The pregnancy rate after rape is also relatively high, and studies from the two world wars indicate that the incidence of pregnancy resulting from married soldiers' one- or two-day leaves is above average, considering the number of wives likely to be ovulating in midcycle.

These births may result from normal ovulation occurring on an unexpected day, early or late in the menstrual cycle, or from additional ovulation during the same cycle. The normal human menstrual cycle is twenty-eight days, but no woman is always regular. Cycles as short as twenty-one days or as long as thirty-five are not unusual. The cycle starts with about five days of menstruation, followed by a proliferative, or follicular, phase; then a secretory, or luteal, phase that lasts until the next period.

After midcycle ovulation, the ovum can probably be fertilized for only about one day. In most women, the time of ovulation is fairly constant. In women with irregular menstrual cycles, the date of ovulation is uncertain because the follicular phase lasts longer; the luteal phase, however, tends to remain about fourteen days long.

When the follicular phase begins, the endometrium (the inner lining of the uterus) is thin and the ovary is inactive. The pituitary gland, situated in a small recess at the base of the skull, secretes gonadotropic hormones that stimulate a follicle in one ovary to ripen. This Graafian, or maturing, follicle contains the ovum, surrounded by a group of smaller cells called granulosa cells. These multiply and secrete an estrogenic hormone that causes the endometrium to grow thicker.

When ovulation occurs, the follicle discharges the ovum into the Fallopian tube, through which it travels to the uterus. After ovulation, the granulosa cells—which line the follicle that the ovum has left—accumulate yellow lipids and are known as lutein cells. The follicle, now called the corpus luteum, continues to secrete estrogens and also begins to secrete progesterone, which induces the secretory phase in the endometrium. If the ovum is fertilized, it embeds itself in the endometrium and starts to grow. If the ovum remains unfertilized and dies, the corpus luteum degenerates and ceases to produce hormones. At this point, all but the basal layer of the endometrium breaks down and is shed in menstruation. The endometrium's residual layer regenerates during the follicular phase of the next cycle.

Although normal midcycle ovulation is occasionally early or late, clinical and experimental evidence suggests the existence of paracyclic ovulation. Some supporters of paracyclic ovulation postulate that it is provoked by psychosomatic influences, such as stress, and that since during coitus the female usually experiences some degree of mental and physical stress, human coitus may induce ovulation. In some animals, including the rabbit, the hare, and the rat, ovulation follows coitus.

Although I think that paracyclic ovulation exists, I am not con-

Please turn to page 32



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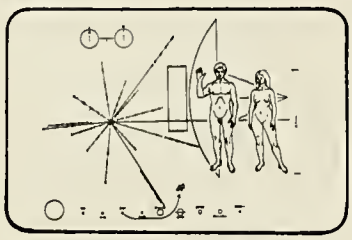
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vinced that it can be induced. Stress generally has a conserving effect on bodily functions, enabling a person to respond with greater efficiency to demanding stimuli. Amenorrhea in first-year college students (and in concentration camp inmates) shows that stress has anovulatory effects. Stress or the physical impact of coitus could hasten ovulation by rupturing a Graafian follicle, but could not hasten an unripe follicle's development so that it could produce an ovum.

Paracyclic ovulation probably occurs at regular intervals, governed by biorhythms that are still unfamiliar to us. This mechanism may differ entirely from that of midcycle ovulation. On the other hand, it may be marked by the same hormonal changes, but the hormones may occur in smaller quantities, so that their workings may be masked by those connected with midcycle ovulation.

Although we know little about paracyclic ovulation, we do have some direct evidence of its existence. During an autopsy on a female body, one investigator found two follicles of differing ages. One was freshly ruptured; the other was a corpus luteum. Obviously, two ovulations had occurred at separate times in the same month. Another researcher concluded from observations made during surgical procedures that ovulation can occur on any day of the follicular phase. And as recently as April 1977, there was a report of a patient with both an intrauterine and a tubal ectopic pregnancy. The intrauterine gestation was twenty-one days old and the tubal twelve. The patient's doctors concluded that she must have ovulated twice during the same cycle.

Indirect evidence of the existence of paracyclic ovulation is less precise, yet worth considering. Conception during amenorrhea has been frequently reported but is actually weak support for paracyclic ovulation. Conception in such instances may have resulted from either midcycle or paracyclic ovulation, whichever came first.

A more positive argument is the claim of many pregnant patients that they conceived at a time other than that calculated by their doctors on the basis of the women's last menstrual periods. These reports have attracted little attention; instead, the patients' reliability has usually been questioned. Many births deviate from doctors' estimated dates of confinement, perhaps because of human variety or perhaps because conception occurred at a different time from that indicated by the last menstrual period.

Paracyclic ovulation would explain the frequent discrepancy between the laboratory test for fetal maturity, the estimated date of confinement, and the actual delivery. According to one calculation, the chance of conception on the fourth day of the menstrual cycle is as high as 10 percent. If conception can occur on the fourth day in 10 percent of all women, the estimated date of confinement could be incorrect by ten days in 10 percent of all pregnancies. Thus, a baby born twenty days early, in the thirty-seventh week of gestation, might incorrectly be considered premature. These inaccuracies can have important clinical consequences: an inducement or Caesarean section might be unnecessarily postponed as premature.

Another instance in which paracyclic ovulation can cause mistakes is the practice of the rhythm method of birth control. A woman using the rhythm method monitors her basal body temperature and assumes that unless it drops slightly, indicating ovulation, she can engage in coitus without risk of pregnancy. Unfortunately, this means of birth control is notoriously unreliable. A British study concluded that rhythm's many failures are due to the occurrence of paracyclic ovulation, mainly in the follicular phase of a woman's cycle.

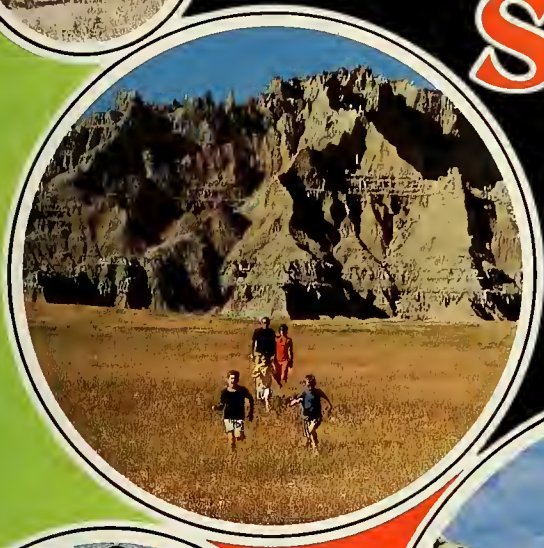
If ovulation only occurs in midcycle, the distribution of births around the estimated date of confinement, allowing for prematurity and postmaturity, should be a symmetrical bell-shaped curve. Fifty percent of babies would be born on or before their due date, and 50 percent on or after. But the great majority of babies are born earlier, rather than later, skewing the distribution curve to the left and confirming the British conclusion that paracyclic ovulation (and conception outside the midcycle) occurs in the first two weeks after the menstrual period.

Incidents of conception after

Please turn to page 36

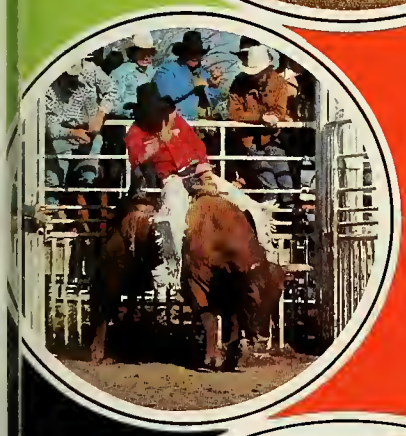


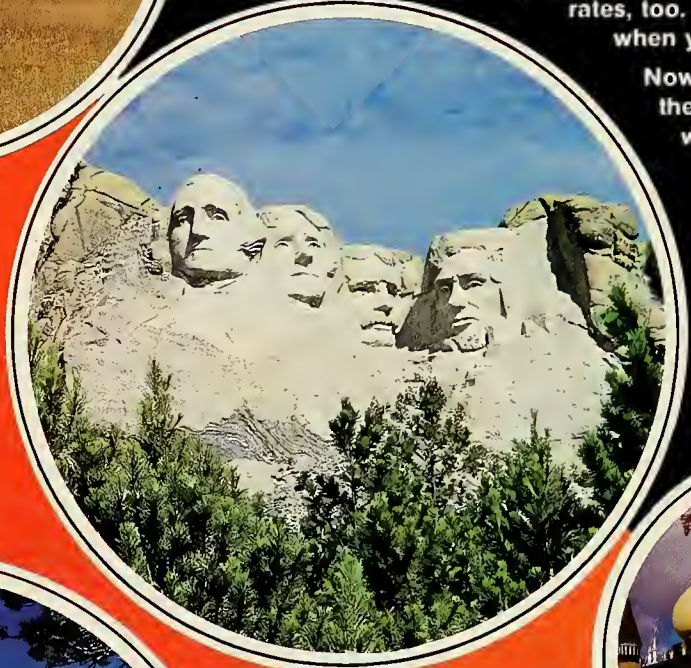
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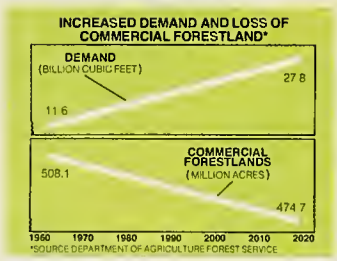


The two red oaks shown here are 58 percent of actual size. Both are the same age. Both grew in Pennsylvania. The big difference is, the larger one grew in a managed forest area while the smaller one did not.

Operation Double Tree: Why it's needed and how it works.

In the U.S. alone, the demand for wood and paper products is expected to *double* in less than 50 years.

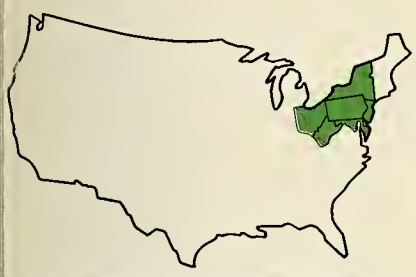
Yet today, only about one-third of this country's total forest is used to grow repeated crops of timber.



That works out to about one acre of trees for every man, woman and child. And each of those acres will have to be carefully managed to provide a lifetime supply of wood products.

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TREE IS WORKING STATES.



The Mid-Atlantic is the most densely populated region in the country, yet much of it today is still forested

land, but showing private landowners how to improve theirs. In the last 15 years it's given away millions of seedlings to these landowners. This is an investment in the future for Glatfelter, since it depends on these private forests for most of its wood resources.

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Recycling is one way to double our forest resources by using them twice. It's a particularly important concept in the densely populated Mid-Atlantic region, where the demand for forest products is high.

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So there's progress with Operation Double Tree in the Mid-Atlantic, and in forests all across the country. But we still have a long way to go.



The hardwoods from this region provide a wealth of fine furniture.



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rape offer an excellent opportunity to study paracyclic ovulation. A post-World War II German study found that in such cases, 39 percent of all conceptions took place during the follicular phase, supposedly before midcycle ovulation; 20 percent during the luteal phase, supposedly after midcycle ovulation; and 8 percent during menstruation. If we accept the patients' reports of the dates of rape and of their last menstrual periods, this study makes a strong case for the existence of paracyclic ovulation.

We do not really know whether paracyclic ovulation is spontaneous or coitus induced. Supporters of human reflex ovulation believe that it is caused by nervous and biochemical interactions during coitus. Exogenous prostaglandin, supplied by the male's ejaculation, is thought to cause the ovary's smooth muscles to contract. These contractions, combined with coital pressure on the follicle, supposedly release the ovum.

However, reflex ovulation remains controversial because without coitus ovulation can and does occur spontaneously every month. In animals that are reflex ovulators, the Graafian follicle ripens in a considerably shorter time. Coitus can hasten ovulation because a Graafian follicle on the brink of maturity is available more often.

In a human, coitus would have to speed up the ripening of a Graafian follicle—which normally requires about fourteen days to develop—so that conception could take place within twenty-four hours or so. If coital stress did release an ovum, there is a good chance that it would be unripe. Overripe ova, whether preovulatory because of delayed follicular rupture or postovulatory due to delayed union with sperm, are known to result in fetal abnormalities. An unripe ovum may have the same unhappy consequences. But among babies conceived during the follicular phase, there is no increased incidence of abnormalities.

Both midcycle and paracyclic ovulation definitely occur regardless of coitus, and successful artificial insemination outside of the midcycle has been reported. This is a strong argument against coitus-induced ovulation, unless any manipulation of female genitalia,

including pelvic examinations, can trigger the neurohormonal reflex that induces ovulation. In cattle, such stimulation releases oxytocin, a hormone that induces cramping of smooth muscle, but no one has demonstrated that ovulation definitely follows.

One thought on the relation between coitus and ovulation comes down to us from the ancient Chinese, who believed that if a woman remained passive or distracted during coitus, she could not conceive. We do not know whether such a woman would be preventing coitus-induced ovulation. She would certainly be avoiding orgasm, which may facilitate sperm movement and relax the Fallopian tubes. But the element of truth in the Chinese belief is canceled out by the success of artificial insemination, the large number of multiparous women who have never experienced orgasm, and pregnancies resulting from rape.

Ovulation must be preceded by an increased output of gonadotropic hormones, which presumably could be measured after coitus. But a 1974 study found that the levels of these follicle-stimulating hormones remained the same after coitus, disproving, as far as I am concerned, the possibility of coitus-induced ovulation. Coitus may hasten ovulation, but cannot induce it. There is no reason to believe that increased coitus, even allowing for paracyclic ovulation, should lead to increased conception. Hence, I predict no increase in the birth rate in New York in April 1978, nine months after the blackout of July 14, 1977.

Of course, as we saw in the case of Pearl Harbor, we will have to allow for exogenous factors. The 1965 blackout took place in the winter, whereas the 1977 incident befell the city during a record-breaking heat wave. Without air conditioning, many people may have preferred to sleep alone. Since the New York City Department of Health's Bureau of Records and Statistics plans to monitor births in April, we will soon know for a second time—in figures, at least—whether high birth rates after blackouts are reality or rumor.

Janos Balog is an obstetrician and gynecologist who teaches and practices in San Francisco.

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The Serendipitous Mouse

by Paul K. Anderson

A breeding strategy in which many surplus offspring are available to emigrate to man-altered environments has helped make the house mouse a human commensal

Human environmental disturbances over the past few centuries have wreaked havoc on many life forms, propelling some species toward extinction. But a handful have actually benefited from man's interference with natural ecosystems. Such species have in recent times increased in numbers, expanded their geographic distributions, and established populations in habitats that are physically and biologically different from those of their ancestors.

I have studied such an animal—the house mouse—to learn what about its biology permitted its exceptional exploitation of opportunities arising out of the changing conditions of the recent past.

House mice still inhabit the arid steppes of central Asia where the species is believed to have evolved. There, like many another rodent, they forage for small seeds and insects. Presumably it was in this ancestral region that house mice first established a closer association with man than have other seed-gathering rodents. The oldest remains of house mice have been found in association with human fossils in Pleistocene deposits on the floors of Crimean caves.

The ability of house mice to coexist with human beings—to exploit man-altered and man-created habitats and to disperse by riding man's vehicles—has led to the establishment of populations under physical conditions, and in association with groups of other species, vastly different from those of the ancestral steppe. House mice now inhabit coconut groves on Guam (13°27′ north latitude) and penguin rookeries on Macquarie Island (54°30′ south latitude). They shelter in the equatorial lava flows of the Galápagos and in the concrete labyrinths of the world's large cities. Some populations inhabit cold-storage plants where the temperature is always well below freezing and the darkness nearly continuous, others occupy the hot tropical deserts of north-central Australia, and still others the mist-shrouded cliffs of the Shetland Islands.

The colonizing ability of the house mouse is, of course, not unlimited. For example, over large continental areas the species is most likely to be found in recently or perennially disturbed locales, such as agricultural fields, and less likely to become established where the native vegetation is undisturbed. But numerous other small, omnivorous rodents have not shown any similar expansion, and my research premise has been that house mice are exceptional colonizers.

I first began to study house mice in 1959, in two quite dissimilar environments. One population inhabited Great Gull Island, site of an abandoned army fort, off the northern tip of Long Island and about seven miles south of New London, Connecticut. The seventeen-acre island was covered with grassland and scattered shrubs; its shoreline stabilized by a covering of trap-rock. There are no permanent human inhabitants. I also studied two groups of mice in elaborate laboratory population cages, which I had constructed at Columbia University's Nevis Biological Station. Each population cage had a floor area of 288 square feet.

One objective of the population cage study was to investigate the possibility that the structural complexity of occupied space significantly influences the behavior and population dynamics of house mice. At the time, there was a good deal of interest in the hypothesis that the size of mouse populations is limited by physiological (adrenal stress) responses to high density. I suspected that in previously published experiments the space in which mice had been confined was not sufficiently complex in structure to permit the animals to interact normally. If this was so, the behavioral and physiological phenomena attributed to a density of a particular number of mice per square foot probably reflected abnormal social interactions, rather than a normal response to crowding. With this in mind, I built each cage eight-stories high, with 128 compartments. Forty-eight compartments opened to externally attached nest boxes, while the remaining eighty contained supplies of food and water. All of the compartments were interconnected, but in such a way that movement through the cage required many twists and turns, and small mice had access to passages too small for larger mice.

I censused my cages every three weeks and recorded the location of the nest box occupied by each individual. Initially, the population of each cage was held at 66 weaned individuals (excess mice were randomly removed at the end of each census). If each cage had been a simple open pen with the same floor area, behavioral and physiological evidences of crowding would have

Karl H. Maslowski, Photo Researchers





Paul K. Anderson



J. Markham; Bruce Coleman

These granaries on the Canadian prairie each maintain a steady population of about ten mice by emigration of the young and rejection of immigrants.

been predicted for such a population density. In the complex, structured cages this did not occur.

My next step was to allow the population in one cage to double in size, while maintaining the complex environmental structuring. In this cage of 132 weaned individuals, behavior, reproduction, and longevity remained normal. In the second cage the population was held at the original level of 66 mice, but hinged partitions between the compartments were swung up against the ceiling, converting the 128 small compartments into 16 long, narrow rooms. The mice responded by an increase in the frequency of aggressive interactions, such as chasing and fighting. The death rate and the frequency of escapes from the cage rose rapidly and drastically, and both were concentrated in the juvenile age group.

By allowing the population in the first cage to double, I reinforced my argument that structural complexity in the habitat was important to the normal operation of mouse society. By simplifying the environment in the other cage, I demonstrated the same point in another way. Also, simplifying the environment (increasing the effective density) resulted in social pressure against juvenile mice, which responded by attempting to leave the cage.

Other interesting observations of house mouse behavior were important to an understanding of the social structure of this species. Even within the small space of the cages, the mice were active only in a part of the available space; that is, they had home ranges. Also, with few exceptions, two adult males never occurred simultaneously in a nest box. Each adult male patrolled and defended a territory and the nest boxes within it.

On the mainland, surplus house mice are potential colonizers. In a study of mice on a small island, three of four annual litters were nonreproductive.

During the three years in which I worked on Great Gull Island, the yearly average of resident house mice was about 140, with early spring numbers as few as 76 and late summer highs up to 497. Since the social structure in the Great Gull Island environment was similar to that observed in the cages, this illustrates the considerable range of population density over which house mice can maintain a particular set of social behaviors. The significance of this social structure becomes clearer when observed in the island context.

On Great Gull Island the mice occupied the grassland and the boulder-covered shoreline, shunning the abandoned fortifications and ruined buildings. Food sources were widely scattered. In summer, seeds and insects were available in the grassland. The year-round staple, and the only major winter food source, was the amphipod crustacean population in the beach wrack.

Through live trapping and recording the tracks of toe-clipped individuals, the movements of individual mice on the island were mapped. Adults of each sex occupied stable home ranges, about 50 yards across, which they defended as territories. Fighting between mice was infrequent. There was only occasional overlap of home ranges among adult females and practically none among the home ranges of adult males. Home range occupancy had a seasonal pattern, apparently in response to food availability. By early spring the home ranges of overwintering mice had contracted to the shoreline. Each range subsequently expanded into the grassland by early summer.

Reproduction begins on Great Gull Island in May and lasts into September. As the young mice mature they pass through a wandering stage in which they may travel the entire 2,400-foot length of the island in a single night. I interpret this as the more normal outcome of the kind of social pressures that were triggered when I simplified the population cage environment. On the island it had some interesting consequences.

Males that had survived the winter were occupying breeding territories by May. Young were born almost entirely in such territories. Most of the mice born in spring and summer, especially the males, ended their wandering phase in certain areas of the island where reproduction never occurred. The areas where the wanderers accumulated could therefore be viewed as "behavioral sinks," which absorbed the bulk of the young born in the early and middle portions of the breeding season. Since they failed to reproduce, these young were a "surplus" population in the island context.

The breeding adults died off each winter and were replaced. It appears that the replacements came, not from the wanderers accumulated in the behavioral sinks, but from the late-season litters; it also appears that the replacements were those members of last-born litters that had not only overwintered successfully but had also inherited parental home ranges. Such inheritance has been observed in a seed-storing race of house mice that inhabit eastern Europe. There a year's supply of weed seeds is stored in an earth-covered hillock by the parents and inherited by some of their last-born young.

There is genetic evidence for this kind of home-range inheritance on Great Gull Island. In 1957, a Columbia University research group headed by L.C. Dunn released six male house mice at the eastern end of the island; each was a carrier for the same mutant allele. This allele had not been found in the resident island population. A mouse inheriting this allele from both parents dies before birth, but a carrier male transmits the allele to 95 percent of his offspring. At least one of the introduced carrier males bred successfully, for in the fall of 1959 I discovered that the introduced allele was common among a group of mice at the is-

land's eastern end. What was most interesting, however, was that it was common only in that group, despite the island-wide wandering of the spring- and summer-born young. The restricted distribution of the allele persisted at least through 1967, probably because the mice that carried the population through the winter and bred the next season were exclusively those that had inherited the parental home ranges and not those that wandered.

To gain a little more insight into the spatial distribution of reproductive activity, I plotted the locations of natal sites, together with the home ranges of breeding adult males and females. This produced a pattern of small breeding groups, each occupying a favorable section of habitat. In contrast, nonbreeders were concentrated in a major behavioral sink in the center of the island (an area of dense, damp grass), with a few scattered in interstices among the breeding group areas.

It may seem wasteful of reproductive effort for a Great Gull Island female to produce four litters when the offspring of the first three merely drift into behavioral sinks and die without reproducing. In a non-island situation, however, these individuals would have been potential colonizers. Thus, at least 75 percent of the reproductive effort would have been devoted to colonization. Departure of the wanderers also insured that a relatively low population density was maintained at the parental site, even though food might be temporarily abundant.

I had an opportunity to explore these phenomena further in 1961 when I moved to the University of Calgary. Calgary is at the western edge of the Canadian prairie grainlands, and there I found well-defined breeding groups of house mice with unlimited food supplies. The grain, which is brought in from the fields in late summer and early fall, is traditionally stored in small, wooden granaries 12 to 14 feet on a side. When filled to the eaves with loose grain in which the mice cannot burrow, such a building provides a structurally simple space, a virtually unlimited food supply, and protection from predators, wind, and precipitation. Grain may be stored in such a building for a period varying from a few months to several years, during which period a colonizing house mouse population enjoys great security and reproduces continually, even during the coldest days of the Canadian winter. Based on the structurally simple population cage experiments of the 1950s, population growth should continue under these conditions until halted by abnormal behavior and physiological stress at a level of about 1,000 mice per granary. In fact, the number of mice inhabiting such buildings, even after several years, is about ten. The crucial difference is that the mice have an opportunity to emigrate.

Further, each granary is defended by the resident adults as a shared group territory. Immigration, even of mice from another granary as little as three feet away, is not tolerated. Intruders experimentally introduced into a granary are attacked and ejected if they do not escape on their own before being discovered.

These characteristics of the granary populations, with their readily recognizable boundaries, display more clearly what was happening in the grassland of Great Gull Island. Specifically, I suggest that house mice organize themselves, to the extent a given situation will permit, into small and exclusive breeding groups that maintain low density by sending surplus individuals out to colonize and by repelling would-be immigrants. This behavioral structuring of house mouse populations occasionally breaks down, for example, in laboratory pens where there is no opportunity for emigration. Under these circumstances, it is not surprising to find that behaviors that usually function to stimulate emigration have pathological social and physiological consequences. (Breakdown of social structuring has also been reported in free-living populations. While the circumstances are not clear, such breakdowns have usually been observed in large areas of superabundant food, such as agricultural fields.)

No habitat is perpetually secure. Even a granary population faces eventual disaster. When grain is removed the abundant food supply suddenly vanishes. The security provided by the full granary with its closed doors is lost as the doors of the emptied building are left open to access by cats, dogs, predatory birds, skunks, and weasels.

I refer to the house mouse as a serendipitous animal. Serendipity is an apparent aptitude for making fortunate discoveries accidentally. The environments exploited so effectively by the house mouse share a high degree of unpredictability: granaries may be emptied; agricultural fields harvested. Steppes are subject to drought, grazing, and fire. Then again, granaries are suddenly filled with grain, fields are planted, and steppes sometimes abound in seed crops.

Behaviors that maintain small, discrete populations in favorable habitats, while generating large numbers of emigrants, are well suited to this kind of unpredictability. The nature and timing of both catastrophes and opportunities for colonization are unpredictable. Its population structure makes the serendipitous mouse well suited for making the "fortunate discoveries" required for its populations to survive catastrophe and exploit opportunity. But there may be something more than ecological serendipity involved.

Over time, a small inbreeding population gains a unique genetic identity. This is a consequence of the small number of original colonists, the persistent exclusion of immigrants that might introduce alleles, and the small number of individuals making up the breeding population. Many years ago, the population geneticist Sewall Wright pointed out that if a species was made up of numerous small, re-

Livestock pellets afford an ample food supply for rodents. However, because they cannot burrow in the loose pile, the storage area supports few mice.

productively exclusive groups, it would be capable of maximally rapid evolutionary change. As inbreeding in isolation reduces the genetic diversity within groups, it increases the diversity between groups. The path of evolutionary specialization taken by each small group would be influenced by chance, both in the selection of the original founders and the results of their matings, and many novel combinations of inherited characteristics would ensue.

House mouse population structure, particularly as represented in the prairie granaries, approximates Wright's model. Among the many genetically diverse small populations generated, the species would have a high potential for producing some that were especially well equipped, genetically, to survive a disaster or exploit a novel opportunity. Since chance is very much involved in the generation of the assortment of available populations, this would represent an "evolutionary serendipity."

In a situation such as I have just postulated, a given population would be competing with other, perhaps less well adapted populations in establishing "daughter" colonies. This implies group selection, a frequently resurrected but generally unpopular concept among evolutionary theorists. A critical question is whether the emigrants leaving a small breeding group tend to mate preferentially with members of their own group. Despite several years of experiments, that question cannot yet be confidently answered. □



Tom McHugh, Photo Researchers



Semana Santa in Seville

by David D. Gregory

photographs by Ken Haas

Holy Week ceremonies in this Spanish city recall ancient Greek and Roman rites of spring

Each spring during Holy Week, from Palm Sunday to Easter Sunday, the Roman Catholic city of Seville in southern Spain transforms itself into Jerusalem at the time of Christ's passion and death. Week-long processions commemorate Jesus' death, and his mother's sufferings and glory. In ritually reliving these holy events, Seville's citizens also emulate pre-Christian Greek and Roman rites that welcomed back Proserpina and other goddesses of spring. The Holy Week processions honor both Christ and Mary, but the Virgin is the more important figure.

Unlike many other northern Mediterranean cities, Seville keeps its past very much alive. Occupied by Moorish invaders for 500 years, the city rose to prominence in the 1500s as Spain's "port of the Indies," through which all the gold and silver from the New World of the Americas passed into Europe. Seville remains the cultural, symbolic capital of Spain's eight southern Andalusian provinces.

During Holy Week, Seville's religious brotherhoods parade with their sacred images. Left, each brotherhood has at least one image of the Virgin.

Religious processions—public affirmations and demonstrations of faith—are common throughout the Mediterranean, but none equals the flamboyant pageantry of Seville. From midafternoon on Palm Sunday to eleven in the evening on Holy Saturday, phases of Christ's passion are reenacted in various versions of the Stations of the Cross, a Roman Catholic penitential prayer ritual for Lent. In the traditional Stations of the Cross, participants recite prayers and meditations and sing hymns at fourteen stations, each representing a stage in Christ's progress from Pilate's chambers, through the streets of Jerusalem with his cross, to Mount Calvary, the site of his crucifixion and death.

In Seville, during Holy Week, each of the city's fifty-three religious brotherhoods (*cofradías*) departs from its neighborhood church, on a prearranged day at a designated hour, and parades through the streets with life-sized polychrome figures that represent the suffering Christ alone, the Virgin in glory or in suffering, or New Testament tableaux, such as the young Christ instructing the elders in the temple. Most brotherhoods have at least two images, one Christ and one Virgin. While some of these hundred-odd figures are of recent origin, made by artisans commissioned by the brotherhoods, many, including one known as "the Sainted Christ of the True Cross," date to the 1500s. Most images require between twenty-four and thirty-six bearers. Some figures weigh nearly two tons and must be carried by forty-eight men.

Each procession retraces the Stations of the Cross from the steps of the brotherhood's church to the last station, "The Cross in the Field," erected in the fourteenth century at the northeastern entrance to the old walled city. Then the procession winds back to the center of Seville; near the courthouse it passes before the crimson-draped reviewing stand crowded with wealthy gentry and important political personages. The procession enters Seville's great Gothic cathedral and, in front of the main altar, receives a blessing from the cardinal, a bishop, or a priest. Afterward, the procession returns to the street and heads toward its home church. Most processions take at least six hours; some last as long as ten or twelve hours.

The climax of Holy Week occurs during the predawn hours on Good Friday. At that time, joining the other parading Christs and Virgins, Seville's two most charismatic images emerge from their sanctuaries: the Macarena Virgin, a 200-year-old image named for a Roman estate where the Virgin supposedly appeared in the early Christian era, and the image of *El Gran Poder,* meaning Christ the King.

As spectators wait along the unlit streets marking the route of *El Gran Poder,* the darkness is punctuated by glowing cigarette tips. The scent of flowers and incense mixes with the scent of the onlookers's sweat and perfume. The street underfoot is slippery with wax from dripping candles carried in previous processions.

Slow, monotonous drumbeats si-





Left, an image of Christ passes, its support blanketed with red carnations. Above, as the Macarena Virgin pauses beneath a balcony, a singer greets her with a saeta, *a song of praise.*

lence the shuffling crowd. A row of candles, their flames flickering in the spring wind, lights up the dark turn in the street as the first figures of the double file of marchers, dressed as penitents and bearing large wooden crosses, come into view. The penitents wear black silk tunics and belts of woven esparto grass. Their heads are concealed by soft black hoods, some are barefoot, and a few drag heavy chains linked to their ankles. *Nazarenos* (marchers performing less arduous penance) dress in similar tunics, but their heads are crowned with high conical hoods, whose shape dates back to the Inquisition. In his right hand each *Nazareno* carries a large, thick candle; his left hand is pressed against his mask so that he can see through the eye slits.

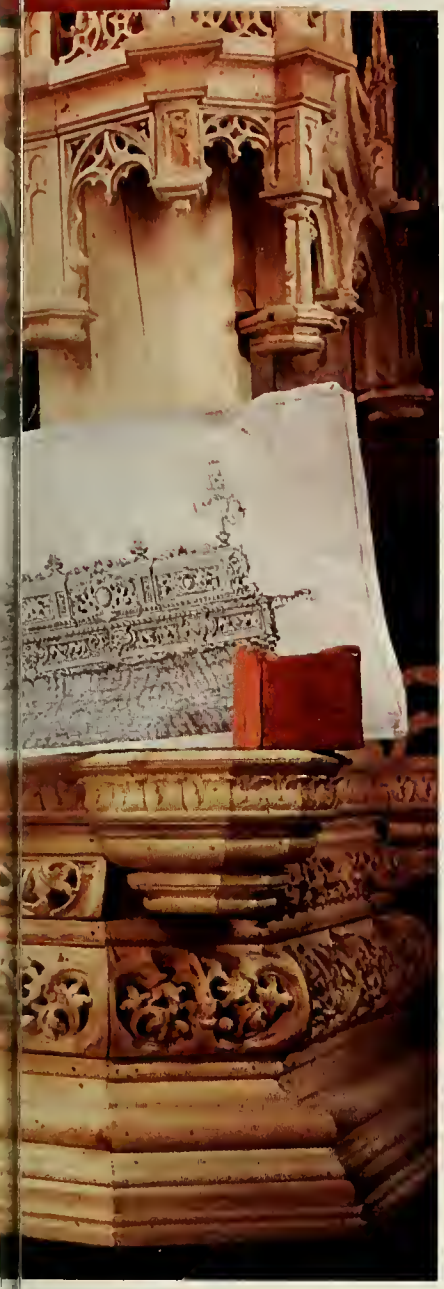
Penitents who walk in the forefront of the procession, farthest from the image, are the newest members of the brotherhood. The

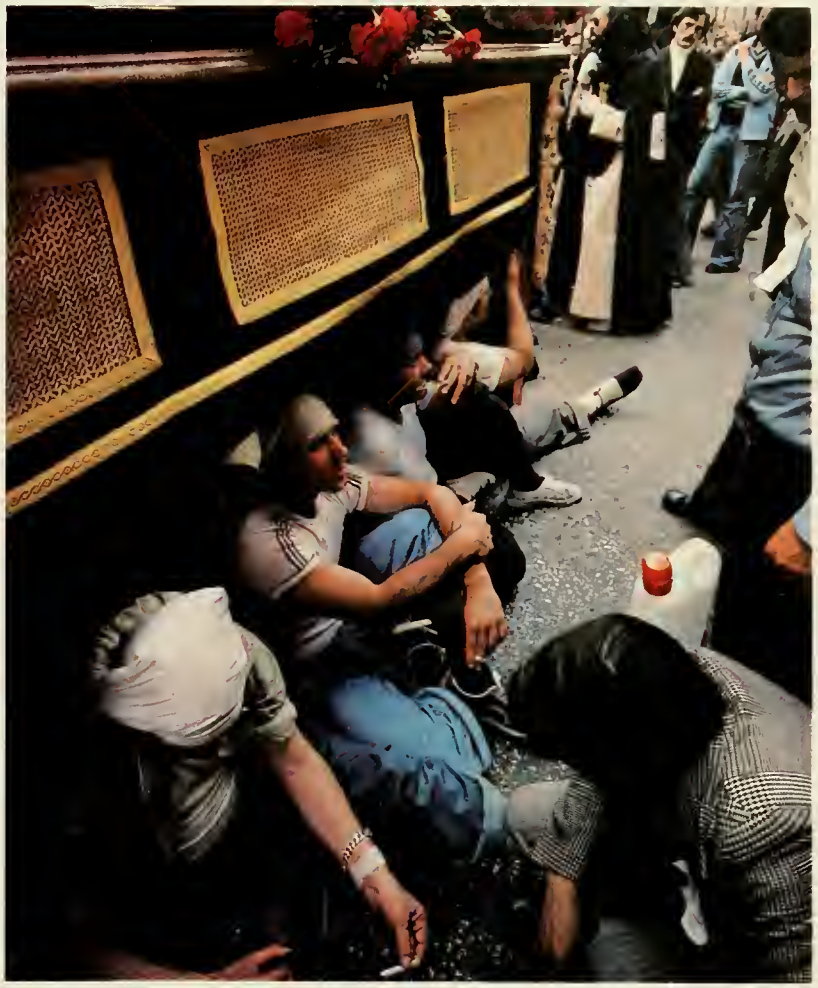


oldest members walk closest to the image, which is borne on a large wooden platform transformed by artisans into a gilded baroque support. Its corners are embellished by four large golden lanterns and velvet curtains hang from its sides, concealing the porters (*costaleros*) underneath. On a thick carpet of red carnations symbolizing the blood of Christ stands the polychrome image of *El Gran Poder*. The cadaverous statue—robed in royal purple, crowned with thorns, eyes closed—drags a cross toward Calvary. Like all Seville's representations of the suffering Christ, whether scourged or crucified, the image of *El Gran Poder* simulates a dying man in minute detail.

A steward (*capataz*) clad in a black suit walks beside the platform. Acting as a stage manager, he strikes three times a small silver knocker attached to the front of the support. The heavy baroque structure stops, and one of the steward's assistants raises the velvet curtains and passes a jug of water to the porters below. Packed in rows six by six, they will carry the platform on their shoulders for at least six hours. They wear working clothes, with wide cloth belts wrapped tightly around their stomach muscles. Wool blankets cushion their heads against the hard platform.

Occasionally, a brother will voluntarily carry an image in the Holy Week ceremonies, but the invisible machinery that moves Holy Week is the porters, working-class men who are not members of the brotherhood. Porters were traditionally recruited from the ranks of the stevedores who worked the Seville docks; nowadays they are chosen, organized, and trained by the steward (a professional who works for the brotherhood), who also acts as intermediary in collective bargaining for Holy Week fees between the porters and the brothers. Porters are paid $50 to $65 apiece to carry







Above left, artisans work year-round to make supports that carry images in procession. Above right, one image's porters rest under their burden. At right, after Holy Week, children organize impromptu processions.

the saints. Accord must be reached before a brotherhood's images can join the procession.

After the procession of *El Gran Poder* passes and the street is again



Members of a brotherhood march in masks and conical hoods that hide penitents' identities from all but God.



engulfed in darkness, the crowd disperses and heads for the light and warmth of the nearest cafés. There the spectators consume wine, beer, cognac, or coffee, and snacks of shrimp, fish, or sugary pastries to sustain them through the remaining hours of other processions.

The somber passage of *El Gran Poder* inspires awe and prompts the faithful to contemplate Christ's sacred sufferings and death, but the appearance of the Macarena Virgin precipitates an explosion of joy. In Andalusia, in the past four hundred years, there has been a successive rise and fall in the popularity of different images of Mary. None, however, has caught the imagination of Andalusians as much as the Macarena. Throughout the year, many young couples marry before her image to enjoy special blessings and good luck. In 1908, Queen Victoria Eugenia dedicated her son to the Macarena. She has been bequeathed estates and titles—held in her name by the brotherhood—and in 1975, her net worth, not counting her basilica in Seville, was more than one million dollars.

In 1977, when the Macarena left her basilica at one o'clock on Good Friday morning, 700,000 spectators were waiting to view her triumphal procession through the city. During her twelve hours in the street, she is accompanied by a brotherhood dressed in white tunics and green hoods, bands playing both religious and popular music, and an elite guard of men dressed as Roman soldiers. En route to the cathedral, the Macarena's porters will stop in one of Seville's many plazas and delight the crowd by making her image move to the bands' rhythms. The dancing movement produces hysteria and pandemonium in the crowds. Elsewhere, the Macarena will come to rest in a narrow street, and the music and spectators will fall silent as a man or woman appears on a balcony to spontaneously sing a *saeta,* a semitonal Moorish-sounding cry of adoration addressed only to the Virgin.

> On the train of your mantle,
> goes my charmed heart, like
> a rose of gold, between
> carnations and lilies.

Behind Holy Week's display of passionate devotion lies the social power of Seville's religious fraternities (*hermandades*) and brotherhoods (*cofradías*), both of which date from the Middle Ages. Each fraternity is a group of men associated with a parish church and its images. The group functions as a sort of lay order, encouraging its members' spiritual growth, promoting the worship and celebration of its cult images, and performing charitable works. In 1977, 70,000 of the 281,000 men in Seville belonged to religious fraternities. *Cofradías* are made up of those members of fraternities who parade with the fraternities' images during Holy Week. One Sevillano in six belongs to a *cofradía.*

Each fraternity abides by a charter originally approved by the Spanish authorities of the Roman Catholic Church. But in recent years, a considerable degree of antagonism has marked relations between the fraternities, which jealously guard their independence, and the religious authorities, who are embarrassed by the brotherhoods' extravagant expenditures in their images'



As a guard keeps watch on spectators, bands accompany brotherhoods' processions.

honor. The archives of most *hermandades* are full of vituperative lawsuits between the members and the ecclesiastic hierarchy involving property title and jurisdiction over images.

Besides functioning as religious organizations, fraternities and brotherhoods also partially define the city's structure. Until the 1700s, Seville was divided into guilds, groups of artisans who lived and worked in specific city streets, and the fraternities were composed of men who shared similar class backgrounds and professions. Today, while the guild system has become a network of barrios, class structure is still strong. Some fraternities and brotherhoods admit members of only one class; others accept both working- and middle-class members. The class and ethnic nature of the fraternities is best described in the membership rules, unmodified since 1661, of the fraternity of Santa Caridad:

> He [the candidate] and his wife must be old Christians of pure and honored generation, without Moorish, mulatto, or Jewish lineage, never convicted by the Holy Office of the Inquisition, nor a new convert to the Holy Faith, nor the descendant of any of these. They may not have base or lowly employment. They should not have been castigated by ordinary justice for ignominious offenses. They must be sufficiently capable to exercise the offices of the Holy Fraternity. . . . And they must have sufficient income or property to sustain the quality of their person.

Members of a fraternity generally live in one barrio. By participating in the rites of fraternities and brotherhoods, in particular the processions of Holy Week, members delineate barrios and establish ties with other neighborhoods.

The intense reverence in which the fraternities hold their images, especially those of the Virgin, arises from their importance as stand-ins for supportive human relationships that an Andalusian frequently lacks at times of personal crises or even in the rounds of daily life. Besides the images' social value in binding together people who share their de-





votion, the sacred figures are important to individual faithful. In northern Spain, images attract generalized devotion, but Andalusians regard them as trusted confidants. Some statues are accorded miraculous powers and are thought capable of curing illness or infertility.

While Andalusians realize that there is only one Christ and one Mary, each is represented in various forms: personifications of important moments in their lives, images accorded particular devotion by certain religious orders, or images associated with local shrines. Similarly, in the classical Mediterranean, the Greek and Roman faithful gave their gods and goddesses multiple forms. Southern Europe has never really broken away from Hellenism's many deities or converted fully to Judeo-Christian monotheism and its attendant illusion that the human ego is permanent and singular. In Spain, a more sophisticated polytheistic psychology exists, taking into consideration the human personality's multiple facets and its diverse, contradictory needs.

During Holy Week, Andalusians turn this internal religious experience into a public event. They consider the Virgin, unlike Christ, a spiritual reality who is loving, lovable, and can be brought down to a human level. Indeed, one day during the week before Holy Week, the Macarena's image is lowered from its shrine to the basilica floor, so that the faithful can approach and kiss her hand. And while *El Gran Poder* is addressed solemnly, Andalusians sing to the eyes, lips, and breasts of the Macarena. She is equal and accessible.

To materialize Christianity and exaggerate its symbols, Andalusians turn to a sensate realism in religious art. Unlike Germany or Italy, where baroque and rococo are now considered stages in the history of art, southern Spain continues to delight in these styles of flowing, twisting movement and florid polychrome colors. This is an art of propaganda, which overwhelms the viewer with luxurious and theatrical effects.

A stranger visiting Seville during Holy Week might easily be convinced that the entire population joins in communal, unanimous adoration of the fraternities' images. In fact, an undercurrent of dissent exists and surfaces periodically. Since the late 1930s, the wealthy landowners who control most of southern Spain have slowly mechanized their farms and the rural population has migrated to Seville in search of work. As a result, the city's population has increased by 400 percent in the last seventy-five years. Migration is not only undermining the barrio structure, the basis of the fraternities' power; it is also weakening devotion to religious symbols. In October 1973, the bishop of Seville declared, "Now only 30 percent of the diocese maintains habitual contact with the Church, and the rest are not Christian actors but spectators; likewise, one can say that anticlericalism is being embraced in Seville, equally among the wealthy as among the working class."

Since Franco's death in 1976, Spanish politics have been liberalized, and church and state have become increasingly separate, as they were during the brief period of the Second Republic in the early 1930s. The effect, if any, on Holy Week in Seville is not yet clear. During Holy Week in 1932, when anticlerical feeling ran very high, only one brotherhood dared leave its church. Its image of Christ was bombarded with rubbish in the streets, and protesters shot at the Virgin as she entered the cathedral. In 1933, no processions braved the opposition, and in 1934 only three brotherhoods ventured out. Throughout 1935, militia desecrated a number of images in their shrines. Frequently, anticlericals attacked neighboring barrios' images while simultaneously defending their own statues. On February 12, 1936, shortly before the outbreak of the Civil War, the Macarena was surreptitiously removed from her basilica and concealed in a private home.

In the 1970s, the strongest critics of Holy Week proceedings have been young worker-priests, who are scandalized by the fraternities' expenditures. The gilded structures upon which the Christ images rest are valued at from $34,000 to $51,000, while the Virgins' supports are worth between $68,000 and $85,000. The Virgins' mantles, embroidered in gold and silver thread, cost about $51,000 apiece, and some Virgins have as many as twelve. Crowns of gold encrusted with precious stones cost $68,000. Flowers, candles, and the porters' salaries amount to between $12,000 and $17,000 per fraternity. Members contribute these huge sums out of their own incomes. The worker-priests, who feel the monies should be spent on social services, protest that the Holy Week spectacle is a slap in the face to the city's many unemployed. But no one protests other expensive festivals elsewhere in Spain, such as the running of the bulls during San Fermin—a Basque spring festival in the northern province of Navarra—or the *Fallas* of Valencia—another week-long spring festival.

In Seville, Holy Week continues because the fraternities and brotherhoods are in great part the city's cultural, social, and economic life. They have kept alive the artistry and craftsmanship in silver, gold, wax, and embroidery that have disappeared elsewhere in Spain. The fraternities' expenditures have supported Seville's small businesses and strengthened tourism. Yet the love and devotion with which the fraternities organize processions year after year quickly contradict the falsehood that Holy Week continues only for the sake of tourists. Holy Week's future will not be determined by politics or economics, but by Seville's children, who become involved in the ceremonies early in life. Weeks after Easter Sunday, children at play reenact the Holy Week processions by taking a kitchen table from their homes, draping it with a bedspread, crowning it with a wooden cross, and carrying it once again through the city streets. □

Holy Week is followed by the Feria de Sevilla, *a horse fair during which the city resounds with gypsy song and dance.*



Seeds in Flight

Seeds dispersed by the wind travel in varied, delicate constructions, portrayed in an architect's drawings

Illustrations and text by Willard K. Martin



Many of us grow up associating summer with clouds of tiny dandelion seeds launched by our own breath. Summer's passage into fall is marked by dried milkweed pods, which split their sides and pour out dozens of silken parachutes, miniature air drops that carry the plant's seeds. Dandelion and milkweed are examples of flowering plants whose seed dispersal depends, not on animals or water, or even exclusively on the plant's own exploding mechanisms, but on the seeds' buoyancy and on the varying movements of air.

Seeds are vital to a plant species' survival because they carry embryonic plants. Over a span of four hundred million years, certain seeds have evolved a great variety of wind-catching dispersal devices—disks, propellers, wings, parachutes, and gliders—some of which have provided models for aeronautical inventors and engineers. In fact, working designers frequently refer to "organic form," without recognizing how many architectural and engineering structures are based on natural ones.

The ovary of the flower contains the developing seeds, along with features that insure their packing, protection, and distribution. Some distribution features rely on animal, bird, and insect carriers; others enable the seed to float, sail, spin, or parachute through the air. The dispersal of the earliest airborne seeds was probably aided by elongated fibers extending from the ovary. These fibers caught the wind and substantially extended the seeds' dispersal range. Seeds with greater flight potential had better chances of survival and subsequently passed on their traits, while limited flyers perished in the shadow of their parent plant.

Some seeds are so light that they need no mechanism to help catch the wind. For instance, a million orchid seeds weigh only about two grams. Because they are so light, these microscopic seeds drop very slowly in air and are widely distributed by wind currents and jet streams, which carry them to great heights and distances.

Many heavier seeds depend on carriers made of a network of tiny hairs—silky plumes or tufts—that trap air and keep the seed buoyant. Formed on the fruit of the plant, these appendages, which make up the pappus, come in a variety of shapes and sizes. Some are composed of hollow tubes; others are feathery bristles. Some seeds, especially those of trees, shrubs, and climbers, have parallel rows of appendages bonded into flat planes, or wings.

Certain flying seeds—of the maple, elm, ash, tulip tree, and most of the cone-bearing trees, including fir, pine, and hemlock—depend on one-winged propellers, or samaras. They use the eccentric wing, or autogyrating, principle of flight, in which the single wing turns by means of its own forward motion. All flying seeds have fixed, or constant, centers of gravity. This stability aids flight and, consequently, dispersal.

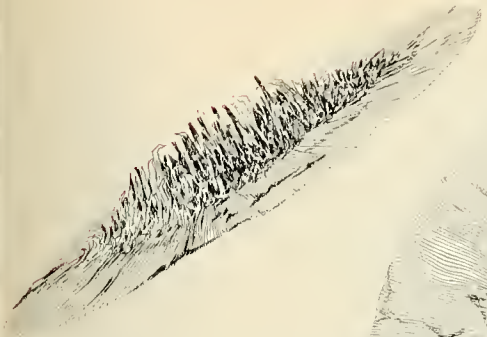
In a maple key, for example, the seed is enclosed in a hard covering that extends into an eccentric wing. A wing operating according to the autogyrating principle revolves automatically around its center of gravity. But a maple seed, placed at one end of the wing, puts the samara off-balance, slowing its descent. When the wind detaches the seed from the tree, the maple key describes a spiral flight, the single wing rotating around a central axis, counterbalanced by the seed's weight. The key, influenced by a current of air, spins like a propeller or windmill. In even a slight wind, a samara can cover considerable distances.

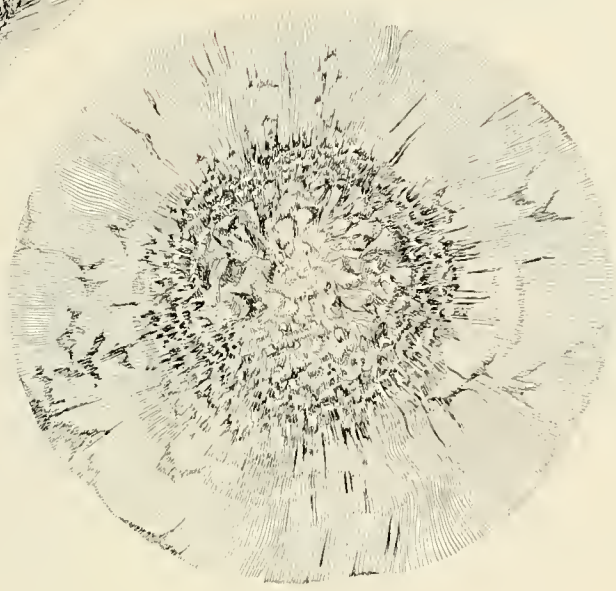


Samaras of *Acer macrophyllum*, or big-leaf maple.



Side view of seed disk



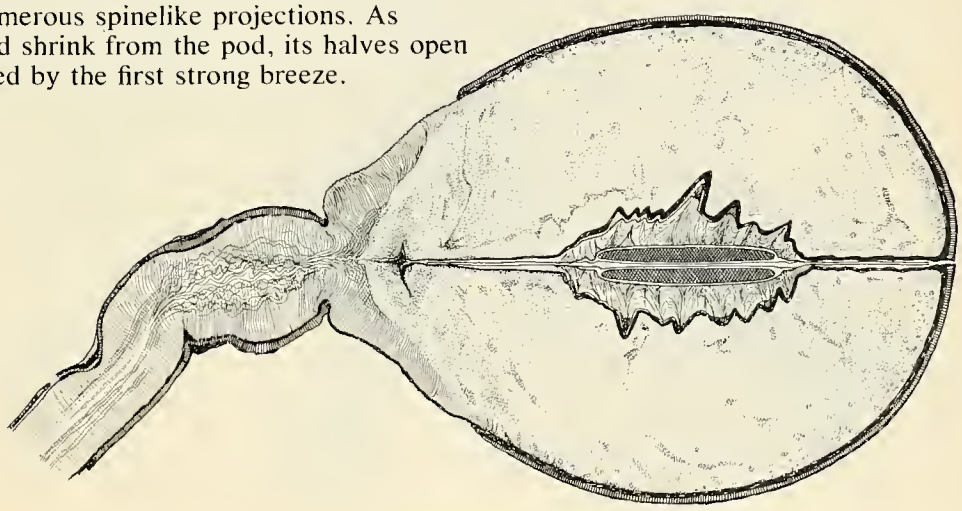


Front view

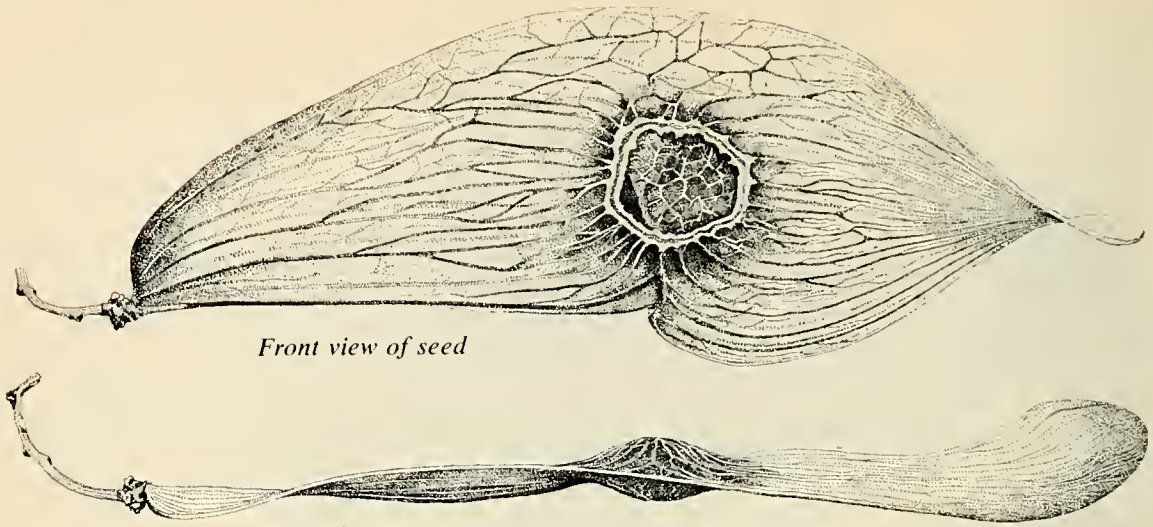
Pod of *Hakea platysperma*, or pincushion tree

Some seeds, such as those of the pincushion tree (*Hakea platysperma*), an Australian evergreen shrub, are simply sandwiched in the center of a membranous halo, or wing. Circular dispersal devices are not as aerodynamic or as stable as the bull thistle's parachutes or the maple's winged seeds. Nevertheless, circular devices can travel great distances in favorable winds. Seeds surrounded by flat, membranous structures are extremely light, allowing them to float gracefully on the least whisper of air.

Hakea platysperma has a heavily insulated seedpod, in which two seeds, each surrounded by a membrane, develop back to back. The outer half of each seed is attached to each half of the pod by numerous spinelike projections. As the spines dry out and shrink from the pod, its halves open and the seeds are lifted by the first strong breeze.



Longitudinal section of seedpod

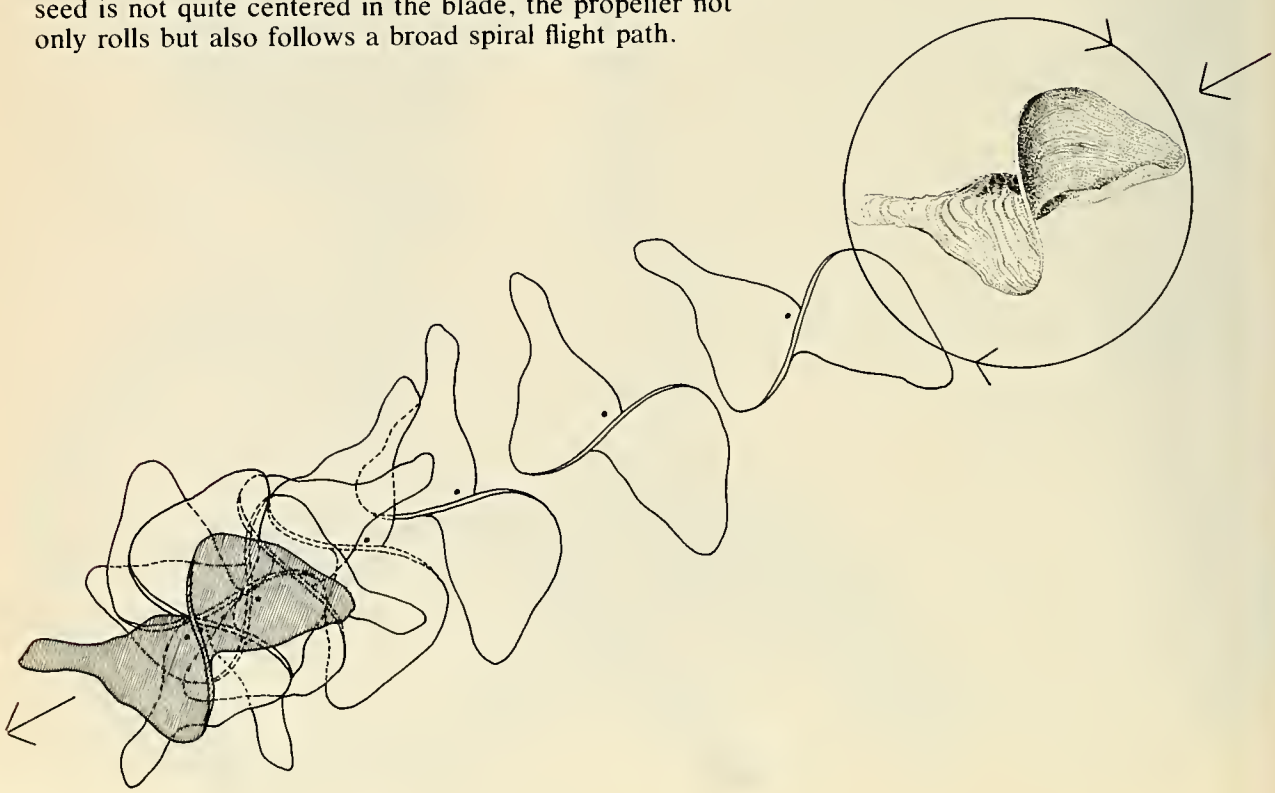


Front view of seed

Side view

Part of a seed cluster of *Ailanthus altissima*, or tree of heaven

Ailanthus and catalpa trees have other kinds of rotating mechanisms, in which the seed is located at the hub of a two-bladed flying propeller. Each blade tip of the ailanthus propeller is warped; consequently, the seed rotates backward as it falls forward. Thus its motion is slowed, enabling it to stay aloft longer and travel farther. Because the seed is not quite centered in the blade, the propeller not only rolls but also follows a broad spiral flight path.

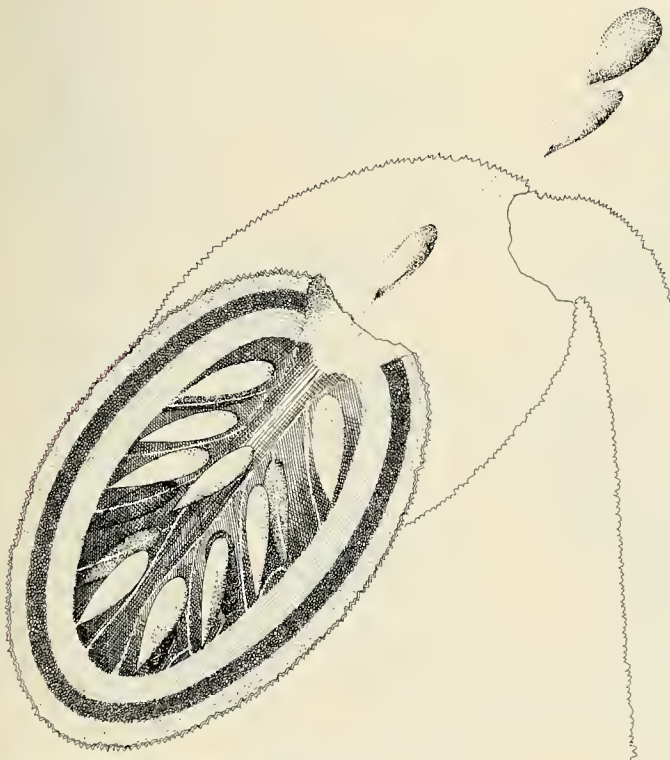




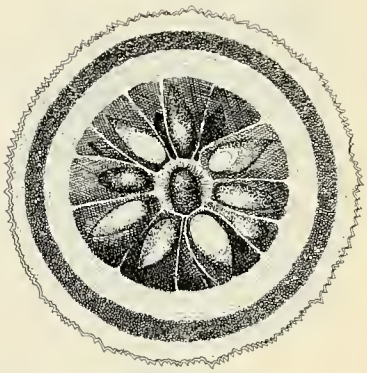


Fruit of *Ecballium elaterium*, or squirting cucumber.

The squirting cucumber actually fires its seeds into the air. The plant's elongated, egg-shaped fruits hang from its vertical stalk at an angle, forming a trajectory that maximizes the seeds' range. Fruits and stalk are connected by cells whose walls eventually separate to form a basal opening through which the seeds are released. As a fruit develops, hydrostatic pressure increases inside it, and its inner, elastic layer becomes very tightly stretched. (A small puncture in the ripe fruit releases a tiny squirt.) Interior pressure and disturbance, caused by movements of wind or passing animals or people, combine to weaken the fruit's attachment to the stalk. The fruit's seeds then squirt explosively from the basal opening. When I bisected several spent fruits, each of which normally contains roughly forty seeds, I could not find any seeds. Evidently, the plant's mechanism is so efficient that every seed is ejected.



Longitudinal section of a fruit ejecting seeds



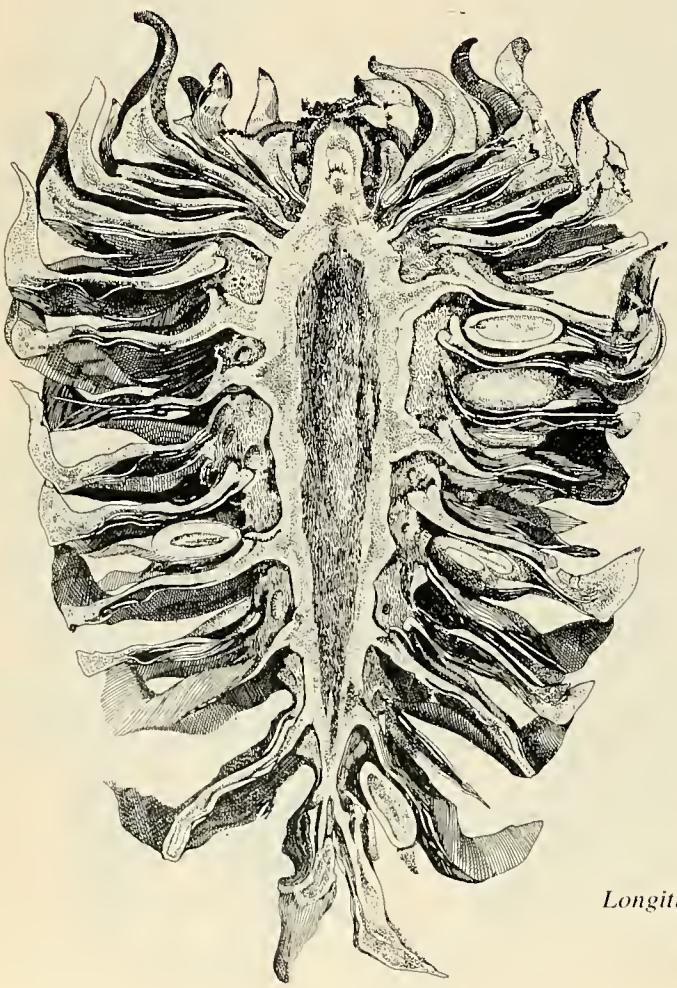
Cross section of a fruit



Seeds

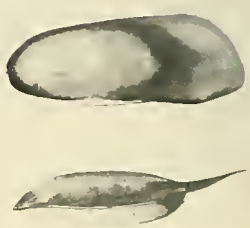
Cone of *Pinus sabiniana*, or digger pine.

The seed of the digger pine has a short, blunt wing that needs strong winds to travel. As the tree's large cones slowly mature and lose their moisture, the cone scales open and release the heavy seeds over several months. Each scale has a layer of coarse, dark, granular tissue, and another layer of very light, dense material. For the scales to open, the coarse layers must expand while the light layers contract. This entire mechanism rotates around a hingelike connection to the cone's core.



Longitudinal section

Seeds

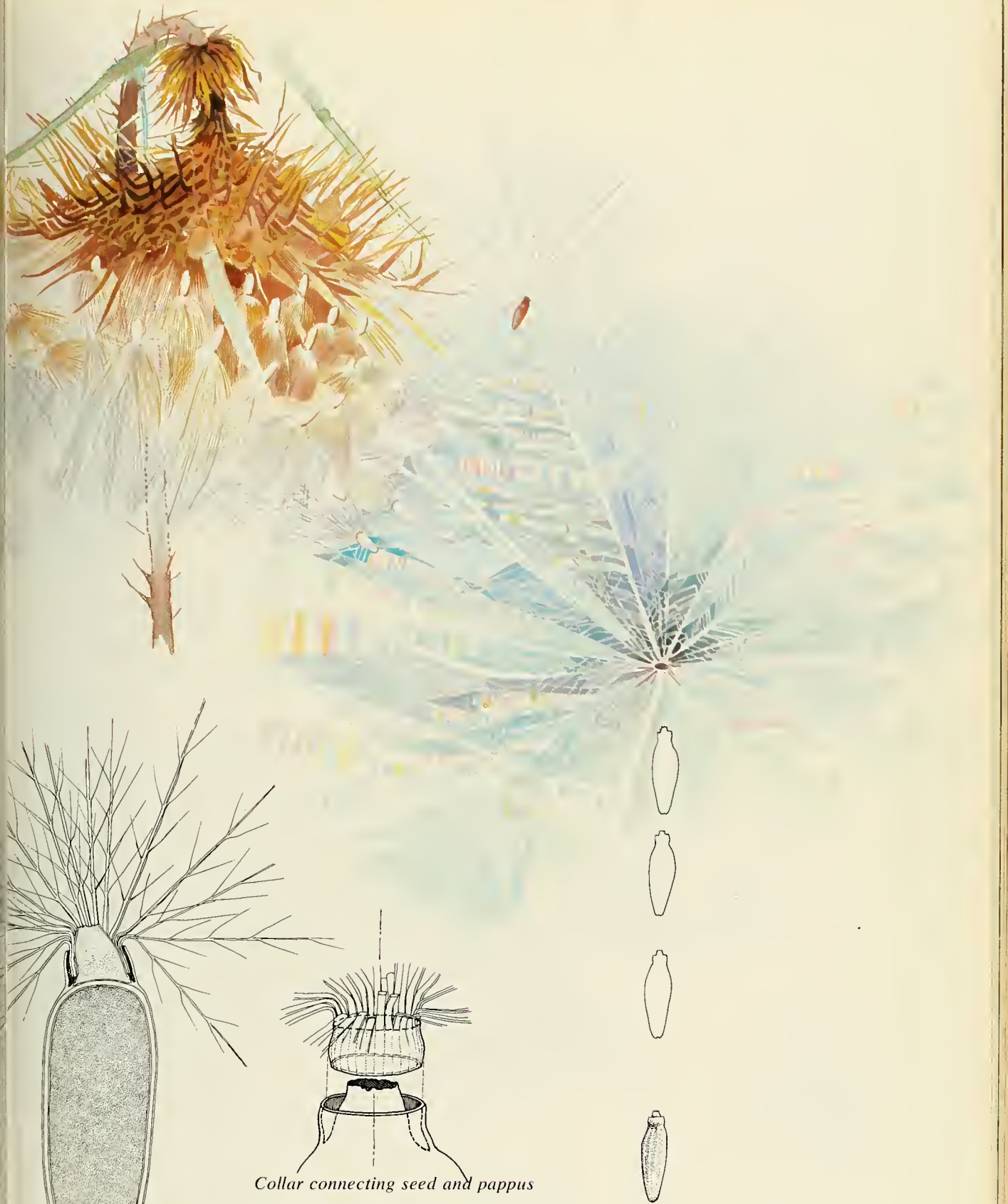






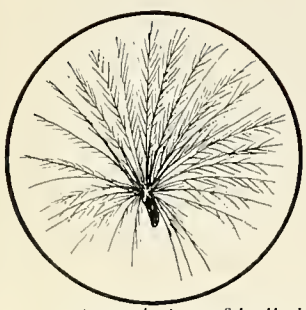
Pappus and seed of *Cirsium vulgare*, or bull thistle.

The pappus transports the seeds of thistles, dandelion, milkweed, sycamore, cottonwood, and goatsbeard. In the bull thistle and the dandelion, the seed is suspended below the pappus, giving the whole apparatus greater stability in flight and insuring that, upon landing, the seed will come in contact with soil. Shaped like spherical parachutes, the bull thistle's pappus rolls and tumbles in the slightest breeze. It dips, then rises again on the next breath of updraft, spanning broad distances in a few minutes and reaching considerable altitudes. Clockwise, from left, an immature bull thistle flower becomes a mature blossom. The dying flower disperses pappus and seeds, and the pappus—a parachute of feathery hairs—releases a seed.



Collar connecting seed and pappus

Seed and pappus



Actual size of bull thistle pappus and seed



The Big Blast at Santorini

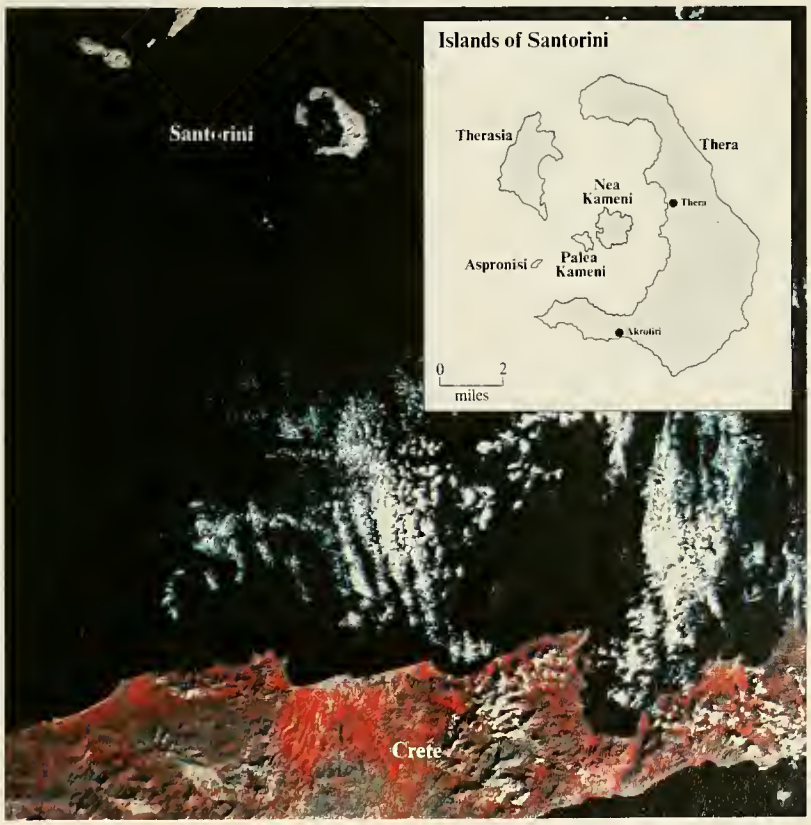
by Stephen Sparks and Haraldur Sigurdsson

Whether or not this volcano effected the downfall of the Minoan civilization, it is typical of the major eruptions that break out every few thousand years

Since the dawn of history, human beings have been fascinated by the destructive potential lying within a volcano. A small number of eruptions have become celebrated because of the havoc they wreaked upon those who lived in their vicinity. In 1973 an eruption on the island of Heimaey, off the southern coast of Iceland, buried a small but important fishing port and disrupted the country's economy for a short while. The 1902 eruption of Mount Pelée, on Martinique, destroyed the town of Saint-Pierre, killing its 28,000 inhabitants. The eruption of Vesuvius in A.D. 79 buried Pompeii without a trace, thereby preserving for posterity a complete Roman town and its way of life. Many people now believe that the paroxysmal eruption of the volcanic Aegean island of Santorini in the late Bronze Age may have destroyed the ancient Minoan civilization.

The Minoans, who excelled in architecture, pottery, sculpture, and painting, controlled a powerful empire centered on Crete, with communities—including Santorini—scattered throughout the Aegean islands. They were a great seafaring people whose economic power derived from trading. By 1500 B.C. the Minoans were at the height of their prosperity and strength, but sometime between 1500 and 1400 B.C. a sudden reversal in their fortunes took place. Archeological evidence indicates widespread destruction and abandonment of many Cretan towns and palaces, most of which were never reinhabited. Although a few palaces were rebuilt, the Minoan civilization never fully recovered. From about 1400 B.C. onward, the Minoans were dominated by Mycenaean Greece and soon thereafter left the stage of history.

The cause of the Minoan decline has been a subject of vigorous debate and speculation. The theory that the Minoan civilization collapsed as a consequence of an immense volcanic eruption on Santorini, some eighty miles north of Crete, was first proposed in 1939 by a Greek archeologist, Spyridon Marinatos. The theory had few adherents until two crucial pieces of evidence demonstrated that Santorini had indeed been the site of one of the largest volcanic eruptions on the earth in the last 10,000 years. First, geologists Dragoslav Ninkovich and the late Bruce C.



LANDSAT #81116082745, EROS Data Center, NASA

The steep cliffs of the island of Thera, largest remnant of the B.C. Santorini eruption, show successive layers of volcanic pumice and ash. Each band represents a separate eruption. The satellite photograph at right was made at an altitude of 570 miles. The red areas are vegetation; many of the small white areas are clouds.

mes A. Sugar

Heezen, from the Lamont-Doherty Observatory of Columbia University, discovered in 1965 a very widespread, thick layer of volcanic ash in cores of sediment taken from the bottom of the Aegean and Mediterranean seas. This ash was identified as coming from Santorini. Second, in 1967 the remains of a large Minoan town were found on Santorini, buried like Pompeii beneath great thicknesses of volcanic ash. Archeological evidence soon established that the town, called Akrotiri, had been destroyed and buried by a huge eruption between 1500 and 1450 B.C.

The great Bronze Age eruption of Santorini is of interest not only for its possible archeological significance but also as a natural phenom-



Dmitri Kessel

enon in itself. It is one of the most recent examples of a type of grand-scale eruption that has occurred repeatedly throughout the earth's geologic history. On Santorini the erosive effects of time, which over millions of years often alter and deform the products of eruptions, have not yet had a chance to destroy the vital evidence. For this reason the Santorini eruption has attracted studies by many geologists, geophysicists, and volcanologists. In 1975 we were part of a team of scientists—led by the late Norman Watkins, a geophysicist at the University of Rhode Island School of Oceanography—that studied the Santorini eruption by sampling sediments taken from the bottom of the sea floor.





Samuel Bishop



These Minoan frescoes, unearthed in the excavations at Akrotiri, have been painstakingly restored and are now on display at the National Archeological Museum in Athens.

Volcanic ash is quarried on Thera for the manufacture of cement, top. Considered of superior quality, much of the product is exported. Center: New houses of volcanic rock rise on Thera amid the ruins of a 1956 tectonic earthquake. The excavation of Akrotiri, bottom, continues under the supervision of the Office of Antiquities of the Greek government. Archeologists hope that additional frescoes and artifacts will be found.



Stephen Sparks



John Caranicas



Stephen Sparks

Our study was concerned with understanding the processes that cause such a destructive concentration of energy in localized parts of the earth's crust and in establishing how these eruptions work. We concentrated on a group of five islands, known collectively as Santorini, which are the remnants of the volcano that erupted. After spending some time on the islands, we joined an international team of a dozen scientists gathered at Iraklion on Crete. We were to spend twenty days on the University of Rhode Island oceanographic research vessel, *Trident*, collecting samples from the sea bottom north and southeast of Crete. We had already learned much about the eruption from observations during fieldwork on the islands; now the team planned to examine the millions of tons of eruption-produced ash that eventually fell into the sea.

A present-day traveler reaching Santorini by boat, as we did on the *Trident*, sees a very different sight from that which a Minoan sailor would have seen before the volcanic eruption. In 1500 B.C. a single island occupied the whole area of the present group of five. There would have been a steep volcanic mountain in the island's north, rising to perhaps 3,000 feet above sea level, and a gently sloping plain would have spread across the southern half of the island. The upper slopes of the mountain would have been covered with dark chunks of lava, while the lower

slopes were probably covered with vineyards that surrounded the town of Akrotiri on the south coast.

Today the whole area is fragmented. The center of the original island was partly destroyed by the volcanic explosions of the great eruption and then, weakened, sank beneath the sea, forming a huge caldera, or circular cavity, about 2,500 feet deep and 6 miles in diameter. Three crescent-shaped islands, with monumentally steep cliffs, rim the vast caldera. The shattering of the original island permitted the sea to pour into the caldera, filling it to a depth of about 1,200 feet. (The rest of the caldera is above sea level.) Since the initial major eruption, periodic and comparatively mild eruptions at vents located in the center of the caldera have led to the formation there of two small new islands.

The earliest recorded mild eruption took place in A.D. 726. According to Greek mythology, however, when Jason and the Argonauts sailed past Santorini, they were pelted with rocks thrown by a giant called Telos, whose feet apparently melted to form rivers of liquid. This may be the oldest extant description of a volcanic eruption. The last eruption occurred in 1950 on Nea Kameni, one of the new islands and the currently dominant volcanic vent. Its active, sulfurous fumaroles belch yellow incrustations of sulfur over the 1950 crater, a reminder of the latent power in the otherwise placid landscape.

The caldera is an imposing sight. The towering cliffs on the remaining eastern half of the original exploded volcano, now known as Thera, plunge steeply into the blue Aegean. The cliffs themselves are streaked with horizontal bands of dark lava and layers of volcanic pumice, rock, and ash, colored from white to cream to brick red. These layers represent the products of many individual eruptions that accumulated over hundreds of millennia to create the original volcano. The snow-white ash of the uppermost layer covers the island like icing on a cake. These white ash layers are the volcanic products of the great eruption.

The volume of rock missing from the caldera exceeds fifteen cubic miles. In the study of other caldera-forming eruptions, a relationship between caldera size and the volume of matter ejected by the volcano has emerged. Although our knowledge of caldera formation does not permit us to assert that the volume of material apparently missing from this caldera is the exact equivalent of the volume of material ejected in the Santorini eruption, there is a clear indication that by any standard Santorini was a very large upheaval.

A great deal about the eruption can be deduced by examining the layers of white ash and porous pumice rock on the islands bordering the caldera. To the uninitiated, the layers of debris may look similar, but to specialists they are distinctive—each one records a different phase of the great eruption. The lowest layer, for example, is composed of large pumice blocks. By measuring the largest of these blocks, hurled from the volcano to many points on the islands, we can find approximately where the original vent was situated. This is because with any volcano, the size of the ejected blocks decreases with increasing distance from the vent.

The opening phase of the Santorini eruption consisted of a violent continuous blast of gas, fragmented lava, pumice, and ash expelled vertically into the atmosphere from a vent about one mile west of the present-day town of Thera. This phase may have lasted for a few days. Laboratory studies of samples of the material ejected indicate the temperature of the lava was more than 800°C (1470°F). The initial speed of this mixture exceeded 1,200 miles per hour. Blocks of rock measuring about three feet in diameter were torn from the vent wall and flung as far as a mile away.

As the hot mixture rose like a huge jet, cold air was dragged into the column. The cold air was heated by contact with the hot ash particles and expanded rapidly. The augmented mixture ascended through the atmosphere to heights of twenty miles or more, reaching the stratosphere. Because the great power of the volcano was directed upward into the sky, the fallout of the fragments would have been relatively slow. But the column reached so far up into the heavens that the colossal volume of debris within it would have spread widely over the land and sea.

The physics of the rising column is similar to smoke rising above a fire or issuing from a factory chimney. As the column rises, more and more air is absorbed, steadily diluting and expanding the mixture. Atmospheric winds blow the mixture in a vast plume over tens of thousands of square miles. Fine ash can be transported many hundreds of miles and some of the dust can remain in the atmosphere for many years.

This type of paroxysmal volcanic activity is often termed "Plinian" after the description by Pliny the Younger of the eruption of Vesuvius. Both Akrotiri on Santorini and Pompeii were buried by lower layers of coarse pumice blocks several feet thick, which were overlain by much finer ash deposits. These coarse pumice beds are remarkably similar in the two towns. In both, the pumice fragments get progressively larger toward the tops of the layers. This finding is thought to reflect an increase in the energy of the explosions within the volcano. Vesuvius and Santorini are representative of a great many volcanoes that show evidence of repeated Plinian eruptions in their history, each eruption followed by periods of dormancy lasting hundreds or thousands of years. The great eruption that formed Crater Lake in Oregon 6,000 years ago, for example, opened with a Plinian blast.

The layers above the pumice bed found on Thera today give evidence of a dramatic change in volcanic activity. The top layer is predominantly fine-grained ash formed by the pulverization of pumice. Such layers are formed when water and hot magma come into contact. In these situations the mixture becomes extremely explosive and the lava is minutely fragmented by intense detonations. We interpret the ash layer as evidence that vast quantities of seawater poured onto the red-hot magma.

From the scientific point of view, the Plinian and water/magma explosions and activity are spectacular forms of volcanism, but they are by no means the most destructive or lethal volcanic phenomena. In a second type of eruption that occurred on Santorini in the last paroxysmal stages, a mixture of intensely hot gas and incandescent solid material shot into the air in an eruption cloud a few miles above the vent. The intensity of the eruption at this stage was so great that the cloud literally collapsed under its own weight, sending dense avalanches of pumice and ash cascading down the volcano's flanks. Such mixtures of hot gas and volcanic fragments move over the land at terrifying speeds. In historic eruptions of this kind known to be much smaller than that of Santorini, speeds of up to 130 miles per hour have been recorded. We estimate that in eruptions of the magnitude of Santorini, speeds of 200 to 400 miles per hour are possible.

The result of these colossal avalanches on Santorini was to spread thick accumulations of pumice and ash over the whole island, burying the town of Akrotiri to a depth of about one hundred feet. This type of burning, hurricanelike eruption probably killed the population of Pompeii with its searing heat and buried the town under a layer of ash. The even fiercer avalanches of destruction on Santorini left behind the great snow-white cliffs visible on Thera today. Paradoxically, a spectacular treasure of Minoan art was preserved amid the violence. Excavations of villas at Akrotiri have unearthed some of the finest examples of Minoan frescoes found anywhere. As with Pompeii, a disaster has allowed us to appreciate the life style of an ancient civilization.

Although studies on the island of Thera are of great value, the cruise on the *Trident* was our main method of examining the effects of the eruption. The vast bulk of the ejected ash was dispersed by the wind and fell into the sea to form a layer that was subsequently buried by sediment washed into the water by rivers in what is now Greece, Turkey, and Crete. During the cruise we collected cores of soft sediment from the sea bottom. Several feet of sediment were recovered, and sandwiched within it, about three to eight inches from the top, we found a distinctive white layer of ash in many of the cores. In the laboratory we were able to establish that this ash, which is distinguished by its unique chemical composition from all other volcanic ashes in the region, came from the great eruption on Santorini sometime between 1500 and 1450 B.C.

The cores collected during our cruise have been the basis of a great many other fascinating studies. Sea-floor sediment accumulates very slowly on the time scale of human life. Only a few inches of mud may pile up every thousand years, so a foot-long core usually records oceanic events that stretch back tens of thousands of years. During this time span, several glaciations may occur. The skeletal remains of microscopic organisms that become buried in the sediment change according to the water temperature. The sediments in cores reflect these changes in subtle ways: for example, the ratio of the two isotopes of oxygen O^{18} and O^{16} changes during glaciations and makes it possible to determine the age of a particular core level.



Contour Map of Ash Thickness

Each contour represents the average thickness of volcanic ash from Santorini found in sea-floor cores.

Black mud in our cores, rich in organic matter and dead deepwater organisms, indicated periods when the sea downwind of Santorini became completely stagnant, like an enormous pond with no circulation. Layers of volcanic ash deeper in the cores than that identified as coming from the great Santorini explosion showed that other large eruptions had occurred in this area tens of thousands of years ago. Some of these deep layers were also from Santorini and we were able to correlate them with the great bands of pumice found today in the caldera cliffs on the island of Thera. Other layers are from other volcanic islands in the Aegean, such as Nisyros and Yali near the Turkish coast.

One important result of our coring provided a great deal of information on the correlation of ash thickness with distance from the islands of Santorini. From these data we constructed a chart, called an isopach map, with contour lines that join sites of equal ash thickness. This map enabled us to determine the wind direction during the great eruption, a principal factor in controlling the quantity of ash that fell at a particular place. We found that the wind had blown the ash to the east-southeast; therefore only the eastern half of Crete was covered with ash.

How did the great eruption affect the Minoans living on Crete and throughout the Aegean? Although the eruption probably lasted for at least several days, its immediate impact would have been confined to Santorini itself. High-altitude winds, however, carried ash of submillimeter size toward Crete and, as the eruption continued, a fine rain of ash fell over much of the eastern part of the island. At the time, the bulk of the population lived in the eastern half of Crete. Where the ash fell thickest, crops were probably destroyed and we could expect the ashfall to have been a considerable nuisance to the Minoans. But we doubt whether such a moderate shower of ash would by itself have been sufficiently catastrophic to destroy an entire civilization. On the other Aegean islands, however, such as Karpathos and Rhodes, and on the south coast of Turkey, the ashfall was considerably thicker. Communities at those locations may have suffered much greater losses.

After an eruption of the magnitude of Santorini, the volcano was weakened to its root and the subterranean chamber, from which the vast quantities of lava originated, was empty. The volcano then collapsed inwardly on itself and the present-day caldera was formed. We can learn a great deal about the probable effects of this collapse from modern studies of caldera formation. In 1968, for example, a great caldera approximately seven miles square and a thousand feet deep formed in the Galápagos Islands over a nine-day period. Some 675 earthquakes accompanied that collapse, and 75 of them approached a magnitude of 5 on the Richter scale. Each of the larger quakes resulted from a drop in the crater floor of approximately thirteen feet. Santorini's caldera is much larger than that of Galápagos and we can speculate that the accompanying earth tremors there were correspondingly larger. Earthquakes in the sea, of course, can form tidal waves and the backlash of the sea rushing into a newly formed pit must have a similar effect. Thus it seems likely that at Santorini both large earthquakes and large tidal waves would have accompanied the caldera collapse over a period of days or weeks.

Even moderate-sized tidal waves hitting the northern shore of Crete could have destroyed the Minoans' ships, the basis of their economy. In antiquity, boats were usually beached, and waves of the relatively modest height of those generated by the 1883 Krakatoa eruption—about forty feet—would have undoubtedly destroyed a great many boats. A seafaring society would have suffered tremendously from these tidal waves. Whether they were sufficiently destructive to have wiped out the Minoan civilization, we cannot say. But archeologists have found pieces of the same vase in different rooms of excavated houses on Crete, indicating that catastrophic flooding probably accompanied the waves.

Many people inevitably ask whether a great eruption such as that of Santorini is likely to occur again. Eruptions of that size do not happen very often on the human time scale, but are common events on a geologic time scale. The older ash layers in our cores demonstrate, as already mentioned, that Santorini and other Greek islands have had several large-scale eruptions in their history. In Japan about twenty eruptions of comparable size have occurred in the last 40,000 years. In New Zealand such eruptions take place every 2,000 to 3,000 years.

Eruptions considerably larger than Santorini's have also occurred. One ash layer in our cores from the Aegean Sea is now known to have come from an ancient volcano close to Naples. The same ash layer is found in cores throughout the eastern Mediterranean from Italy to Cyprus. Probably about one hundred cubic miles of ash were ejected during this cataclysmic event, yet the eruption took place only 30,000 to 40,000 years ago. This eruption dwarfs even Santorini's. An area within a radius of fifty miles of present-day Naples was deluged with enormous masses of mixed gas and volcanic solids burying the land to a thickness of one hundred feet. Our cores show that the ashfall from this colossal prehistoric event was more than two inches of uncompacted material in the Aegean Sea and on Crete, a band slightly thicker than the Santorini ash layer. It is sobering to remember that Naples is 750 miles from Crete, whereas only about 80 miles separate that island from Santorini.

Probably a few eruptions of comparable magnitude to Santorini have occurred since the Bronze Age, but they have taken place in remote and inaccessible parts of the world and records of them are either scanty or nonexistent. We estimate conservatively that at least one or two eruptions of Santorini's size may occur every thousand years. Thus far, mankind has been lucky that few eruptions of the scale of Santorini have occurred near centers of concentrated population or advanced civilization. □

When Ignorance is Bliss

THE ENCYCLOPAEDIA OF IGNORANCE, edited by Ronald Duncan and Miranda Weston-Smith. *Pergamon Press, $30.00 hardcover; $20.00 paperback, 433 pp.*

This review is a warning. *The Encyclopaedia of Ignorance* is a bad book that will give very little pleasure to anyone. The idea behind it is sound, the title is fascinating, but the execution is so poor that the book is almost a complete disaster.

Fixing the blame is easy. There is ample evidence that the two editors know next to nothing about the task they undertook—to have leading scientists each give "his personal views in simple language on those questions which seem to him to be most important for the future of Mankind."

This idea sounds remarkably easy to carry out: simply pick up the phone and ask the leading scientist in each field to write a brief essay from the depths of his or her wisdom about the frontiers of research. But only someone who is totally unacquainted with the nature of scientists and science writing can retain a belief in such simplicity. A brief consultation with any editor who has worked with scientists is enough to make one aware of a large number of pitfalls.

To start with, only a few scientists know how to write for the public—and the definition of "public" includes other scientists. Most physicists today know very little about biology, and solid-state physicists often need an introduction to the concepts used in, say, astrophysics. To write for the public, one must provide a good deal of background information, define terms and concepts carefully and fully, lead the reader along slowly, and explain points of controversy in full, including the facts supporting each point of view.

Most scientists are accustomed to writing only for other scientists in their own narrow field. There is a formula for this sort of writing that makes life easy for the writer but not the reader. The scientist assumes that the reader is equipped with a full knowledge of the subject. The background given is minimal. The jargon of the field is used with little or no attempt at definition. Other scientists are referred to by last name only; for further information, the reader is referred to other papers, often in journals known only in the field. The scientist slips easily into mathematical formulas when they are necessary to carry along the flow of the argument. If the scientist is interested in one narrow aspect of a broad field, most of the paper will be devoted to that narrow point. And if the scientist has a theory in an area of controversy, that theory will be supported passionately.

If the editor is not dealing with Solomon Snyder or Jeremy Bernstein or Stephen Jay Gould or any of the other, small number of scientists who know how to write for the public, iron discipline is needed to keep the contributor in line. Any attempt by the scientist to dust off a published scientific paper without change must be rejected ruthlessly. Attempts to sneak in scientific terms without definition must be suppressed without mercy. (It can be argued that the art of giving definitions easily is half of science writing.) The scientist must not be allowed to ride his or her hobbyhorse; all sides of an issue must be presented. Jargon must be driven out of the article completely.

The effort to turn a typical scientific paper into a piece of intelligible science writing for the public is exhausting—so much so that most editors prefer not to deal with scientists at all. When an article does appear under a scientist's name, it often is the result of a long and careful collaboration between the scientist and an editor who has put in many hours of work to turn out a readable but accurate account.

There are many dangers in this process, and the editors of *The Encyclopaedia of Ignorance* have not escaped a single one. This is not surprising, since neither seems qualified for the job. Ronald Duncan is described as "the well-known poet and playwright." Miranda Weston-Smith is described simply as "the granddaughter of the great cosmologist E. A. Milne." One can picture the cocktail party at which some publisher thought it might be a lark to turn this project over to them. It was a mistake.

Now to particulars. The first section, on the physical sciences, can be briefly described as a total loss. It is possible to make a list of some of the more interesting questions in the physical sciences today.

Ground Floor Opportunity Welcomes You To the *BOOMING NEW FRONTIER IN SANTA CRUZ, BOLIVIA*

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Once there was a great American frontier in the West. Cheap fertile land and not many people to work it, opened up wonderful opportunities for generations of Americans, and immigrants too. Many prospered, many grew wealthy profiting from the development of the land and the nation's expansion.

THOSE DAYS ARE SADLY GONE EXCEPT — *YES* EXCEPT FOR ONE PLACE — THE VAST TEMPERATE ZONE OF VIRGIN LAND IN THE STATE OF SANTA CRUZ, BOLIVIA

AREA TEEMS WITH ACTIVITY AND NEW WEALTH

The Bolivian frontier is bustling with activity: vast new farming areas are being opened up for cotton, soya beans, and corn; pasture lands in the north are being developed as cattle ranches; new oil and gas discoveries are being made; mineral exploration is going forward; and plans are underway for a steel mill complex using natural gas for energy with estimated reserves of 40 billion tons of iron and manganese.

A REPORT BY THE BOLIVIAN — UTAH STATE/USAID STUDY TEAM IN 1972 CONCLUDED: . . "THE EASTERN PLAINS OF BOLIVIA SHOULD BE CONSIDERED AS ONE OF THE WORLD'S OUTSTANDING POTENTIALS FOR AGRICULTURE DEVELOPMENT." *THIS POTENTIAL CAN BE YOUR "GROUND FLOOR" OPPORTUNITY.*

All of these activities are centered around the City of Santa Cruz de la Sierra, the booming capital of the State of Santa Cruz and Bolivia's second largest city. Santa Cruz de la Sierra was founded over 400 years ago, but it was connected to the outside world by little more than an ox cart trail until a paved road was completed in 1955. Then oil and natural gas were discovered, making Bolivia more than self sufficient in petroleum (gasoline is just 40 cents a gallon in Santa Cruz). The oil and gas discoveries were followed by the boom in cotton. Today, Santa Cruz is a major producer of oil, natural gas, cotton, sugar, rice, corn, wheat and cattle. There is a petroleum refinery, 16 cotton gins, 5 edible oil extraction plants, 4 sugar mills and a burgeoning industrial park. There are plans for a cement mill, a can-making factory, a paper mill and a major textile plant.

The State Government of Santa Cruz has an average income of $20 million from oil royalties and has used this money wisely to encourage the industries and services needed for full rapid development. Santa Cruz de la Sierra has grown more than five fold from 42,476 in 1950 to 255,568 in 1976, and is expected to reach over 800,000 by the turn of the century.

This is still a frontier city, yet according to the *New York Times* of 4 December 1974: "Unlike any other Bolivian city, Santa Cruz has a large and growing middle class . . ." Speaking of Santa Cruz, the *Financial Times* of London said: "The Crucenos are renowned for their independent mentality. The old world colonnaded streets echo to a cowboy philosophy of free enterprise and survival of the fittest. 'This is a place where people can get things done' is something you hear at every turn." (8 February 1977).

People who want to "get things done" have been coming to the State of Santa Cruz. First there was the Japanese immigration from Okinawa, and today 30 miles north of Santa Cruz de la Sierra is the prosperous agricultural colony centered around the new Bolivian town of Okinawa. Then in the 1960's the first large wave of English speaking Menonites arrived, mostly from Manitoba, Canada and later more from Paraguay and Mexico. This well known religious farming group, generally called Pennsylvania Dutch in the United States, were seeking rich farming lands in a country where they could live in peace with a minimum of governmental interference in their community affairs. They came to Santa Cruz, Bolivia!

Today there are about 11,000 Menonites in various farming communities. They are virtually self sufficient, raising their own fruits and vegetables, dairy products, poultry, beef and pork, plus large acreages devoted to cash crops, mostly soya beans, wheat and corn.

The Bolivian Government has indicated a willingness to accept European farmers from Rhodesia, Namibia and South Africa to settle in its unpopulated areas, and this new immigration is just beginning. While the foreign immigration has been going on, many industrious Bolivians fromother areas have also settled in Santa Cruz.

According to the *Wall Street Journal:* Bolivia's economy shows strong elements of stability (Feb. 8, 1977) "The inflation rate . . is infinitesimal by Latin standards" (June 3, 1977) and "Consumer prices rose 4.6% from 1975 to 1976" (The Times, Dec. 13, 1977).

ENTERPRISING PEOPLE WANTED

Bolivia is looking for enterprising people to help develop its resources. There is a generous tax incentive program for agricultural enterprises and there are boundless new business opportunities in supplies and services to the burgeoning activity and population. Santa Cruz is well served by both State and foreign banks, including the First National Bank of Boston and the Bank of America.

The State of Santa Cruz is Bolivia's richest and biggest, with a population of around 700,000 and a third of the country's area. The population of Santa Cruz is growing at twice the rate of the rest of Bolivia, which has a total population of 4.7 million. Santa Cruz is estimated to have 65 million acres of useable land, but only 2 million are being farmed. The land is the real wealth of Santa Cruz, and this is where the opportunities are greatest.

> "As far as the eye can see, it's one vast area of potential farm land broken only by stands of virgin timber." *Wall Street Journal,* (3 June, 1976).

VIRGIN LANDS

The Anglo Bolivian Land and Cattle Company has conducted a thorough search of the best undeveloped agricultural lands in Santa Cruz. We have screened hundreds of offers of undeveloped land and accepted only those with completely clear legal title, suitable soils, acceptable rainfall, and good access to the city of Santa Cruz de la Sierra.

This is heavily forested land, classified by ecologists as "temperate dry to moist forest." There is a sufficient rainfall of at least 40 inches most years, mainly from November through March. Once cleared of forest and properly prepared, this land is ideal for cotton, soya beans, corn, wheat, pineapples and peanuts. This is not jungle land or tropical rain forest, such as is being cleared in parts of the Amazon basin. Ecologists and soil scientists have serious doubts about the advisability of clearing tropical rain forest for grazing and agriculture, but the temperate wooded lands of Santa Cruz are ideal for agricultural development.

LAND READY FOR WORKING

The undeveloped land can be immediately cleared for agriculture, or just partially cleared, and in either case farmed individually or leased to a tenant. Alternatively the land can be left in its natural state for recreational use and value growth. A small site can be cleared for a house. Construction of a simple but adequate dwelling costs less than $5 per square foot.

ACCESS TO SUPPLYS & MARKETS

All of the lands selected by Anglo Bolivian Land and Cattle Company are alongside or near major road projects or existing railroads and have adequate road access.

LAND VALUES INCREASING

In the past, prime undeveloped land in Santa Cruz has appreciated between 15 to 20 percent annually. There is, of course, no guarantee that this rate of increase in value will continue. Developed land generally has a far greater appreciation, and the major opportunity is in improving the undeveloped land.

It must be remembered, though, that this is a frontier. The weather is generally quite mild, but it does sometimes get hot in the summer, and even down to the low forties (Fahrenheit) during the winter. There are insects that bite. The roads can occasionally be muddy during the rainy season and dusty during the dry. Transportation is mostly by four wheel drive vehicles and trucks.

FERTILE SOIL — ABUNDANT GAME

But this land has its own rewards. The soil is fertile, and the forest is populated by a wide variety of game animals and birds: the collared and white lipped peccary, white tailed and brocket deer, tree turkeys, partridge, grouse and dove. Most of the other species are protected under Bolivian law including the jaguar, puma, ocelot, margay, brown capuchins, grey fox, coati and parrots. The bird life is prolific.

AN INVESTMENT FOR THE FUTURE

Buying undeveloped land in Santa Cruz affords you the opportunity of being a modern day pioneer helping to solve the Earth's growing food problem while profiting from your work, talent and enterprise. Furthermore, with good land management, you can also preserve much of the native fauna and flora. For the less active, it provides the basis for an appreciating investment, with the added possibility of recreational use for second home development, camping, hunting and nature study.

It's something to think about for your children's future — anything from 160 acres to a solid square mile of land for them to develop. This is an outstanding opportunity for them to learn about pioneering life in a developing country.

EASY TRAVEL ARRANGEMENTS

Travelling to Santa Cruz from the United States is very simple. Just come to Miami and then board a Lloyds Aereo Boliviano Boeing 727 direct to Santa Cruz de la Sierra, which has its' own international airport (and plans to build a bigger one yet)! In Santa Cruz you can stay at the modern Holiday Inn, Los Tajibos, or any number of other pleasant hotels.

WE INVITE YOU TO VISIT US IN SANTA CRUZ

Once you are in Santa Cruz, you'll probably want to explore the rest of fascinating Bolivia: the thriving capital of La Paz, the untouched colonial city of Sucre; the famous mining center of Potosi, once the largest city in the Western Hemisphere; the delightful flowering city of Cochabamba; the beautiful Lake Titicaca, and many virtually unexplored Inca archiological sites.

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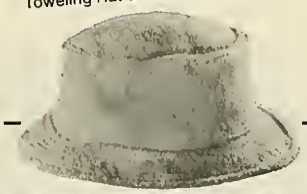
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Will the universe expand forever or will it begin to contract? How do supernovae occur? What are the chances of communicating with other intelligent species in the galaxy? What is the energy source of quasars? And so on.

None of these questions is discussed at any length in the first section; most of them are not discussed at all. Just as distressing as the omissions is the clear indication that the editors do not know the difference between important and unimportant topics. Abdus Salam, one of the great names in physics, writes an excellent article on the nature of matter—a topic of major importance—that is only a page and a half long, while more than nine pages are spent on a detailed discussion of the atomic nucleus, which is of interest to specialists only.

Confusion reigns. John Wheeler is allowed to reprint a highly technical scientific paper on the microstructure of matter, which hardly anyone without an advanced degree in physics can understand. One is surprised to see the same subject discussed more understandably and more briefly only a few pages later by Paul Davies. One contributor, Thomas Gold, is permitted to write exactly four paragraphs on his chosen subject, relativity and time. Almost all the articles are heavy with mathematics, and nothing is defined for the sake of the ordinary reader—nothing at all.

Someone who knows a great deal already and works very hard may get some useful information out of the first section. The same information can be gotten more easily from many other sources.

The second section, on the life sciences and earth sciences, is better, but only by comparison. It has one completely successful article, by John Maynard Smith, on the limitations of evolutionary theory, and several others that are worth reading. But again, the evidence of poor editing and ignorance of the subject matter are everywhere.

Three of the most exciting subjects in the life sciences are slow viruses, recombinant DNA research (or gene splicing, if you will), and brain chemistry. The first two are not mentioned at all; the third is mentioned only in passing.



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Just to show how the editors handle their subjects, on page 367 a brain chemical is spelled "enkephaline" and defined as "a naturally occurring substance in the brain" that "has narcotic properties." It is spelled "enkephalin" and defined as "a specific opiate receptor in the brain" on page 372.

The first writer has the spelling wrong and the definition right, while the second writer has the spelling right and the definition wrong. A reader is entitled to wonder about the level of expertise shown by an editor who will allow such an obvious inconsistency to get into print. A reader is also allowed to wonder about the level of knowledge of an editor who devotes more space to a discussion of the unanswered questions of leaf structure and function than to a discussion of the unanswered questions of immunology. Leaf structure may be interesting; immunology is a matter of life and death.

One could go on and on. Why have Ewan Cameron and Linus Pauling been allowed to present their enormously controversial (to be as polite as possible about it) theory that vitamin C prevents cancer? Why has a literary gentleman whose only listed qualification is "a strong interest in the philosophical implications of the life sciences" been allowed to write a paper based on the untenable statement that the Darwinian view of evolution has been discredited? Why is a writer allowed to get away with a sentence like this: "A fragment of the toxin, known as fragment A, which has a molecular weight of 24,000 D and is released from the complete toxin by trypsin and dithreitol, has been shown to catalyse the transfer of adenosine diphospho-ribose from diphosphopyridine nucleotide (NAD) coenzyme to an enzyme known as elongation factor 2 (EF2, aminoacyl transferase I), translocase II."

That last sentence gives the general flavor of the book. Not much more need be said, except that even in these days of high book prices, $20.00 seems excessive for two paperback volumes (one volume in hardcover) that total 433 pages and are generous with white space.

Edward Edelson is the science editor of the New York Daily News *and the author of several books.*

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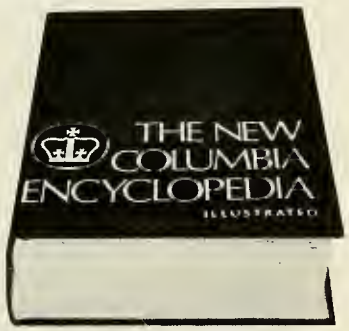
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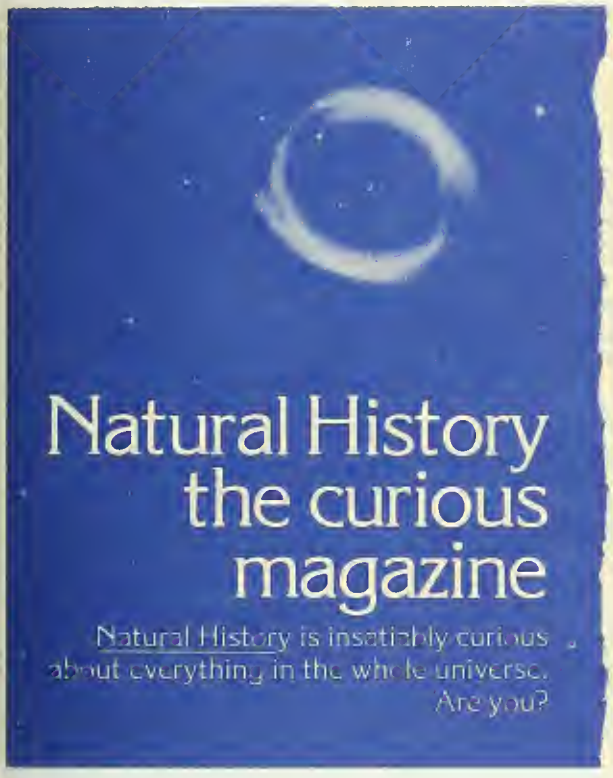
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Celestial Events

by Thomas D. Nicholson

Sun and Moon The sun is moving east and drifting north through the stars of the constellation Pisces in early April. It moves into Aries about the 19th and into Taurus about May 14. It is then located very nearly 20 degrees north of the equatorial plane. By mid-May, the duration of daylight (from sunrise to sunset) in the Northern Hemisphere will be 14 hours 23 minutes in the mid-latitudes, only 40 minutes less than its duration at the summer solstice.

The moon is in the morning sky in early April, and first becomes visible in the evening as a slender crescent, near the planet Venus, about the 8th or 9th of the month. The position of the moon's orbital plane at sunset at this time of the year is favorable for viewing the early crescent during evening twilight. After its appearance as a waxing crescent, the moon will remain a prominent evening object through the first-quarter moon of April 15 to the full moon of the 22nd. Thereafter it will wane, rising progressively later after sundown, through the last-quarter moon of April 29 and the new moon of May 6. The next evening moon will show up as a crescent about May 8, reach first-quarter on May 15, and full on May 22. Perigee moon occurs on April 26, apogee on April 14 and May 11.

Stars and Planets Until April 11, when Mercury becomes a morning star, all the naked-eye planets will be in the evening sky. And except for Mercury (too close to the sun to be easily seen), all are prominently on display on the evenings of April and early May. Look first for Venus, well up in the west during the early twilight, recognized by its brightness (it is *not* a "flying saucer," although it is often mistaken for one). On April 8 and again on May 9, the early crescent moon will be near Venus, and on May 6 the planet will be moving south of Aldebaran, in Taurus. Well to the left of Venus, and much higher in the sky, Jupiter is nestled among the bright winter constellations, Orion beneath it and Auriga above, Taurus to its right and lower, Gemini to the left and higher. But Jupiter is far brighter than all the stars of those constellations. Close to Pollux and Castor in Gemini, to the left of Jupiter, Mars is picking up speed as it moves to the left below Pollux, but dimming rapidly from its brightness of last January. Still farther left, in the southeast, Saturn is close to, and even brighter than, Regulus, the brightest star of Leo. (Saturn is to the right of Regulus.) Jupiter and Mars set about midnight; Saturn before dawn.

April 7: A partial solar eclipse occurs in the Antarctic.

April 11: Mercury, in inferior conjunction, becomes a morning star. The moon covers Aldebaran over northwestern North America.

April 12–13: The moon is near Jupiter on both nights.

April 15–17: The moon is moving past Mars and Saturn.

April 22: The Lyrid meteor shower (about 15 per hour) reaches maximum.

April 23–25: Mercury and Saturn resume their easterly motion.

May 5: The Eta Aquarid meteor shower (up to 20 per hour) reaches maximum. The star near Venus is Aldebaran.

May 8–9: An occultation of Aldebaran by the moon is visible over northwestern North America. The crescent moon is near Venus. Mercury reaches greatest westerly elongation.

May 10–11: The bright object near the moon is Jupiter.

May 13–15: The moon moves past Mars and Saturn.



★ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:20 P.M. on April 1; 10:25 P.M. on April 15; 9:25 P.M. on April 30; and 8:25 P.M. on May 1; but it can also be used for an hour before and after those times.



Helmut Wimmer

Hunting the Elusive Vela Pulsar

Time, patience, and the newest equipment were needed to track down this dim object

After eight years of searching, astronomers have finally detected a second optical pulsar. The first was found in 1969 in the Crab nebula. By now, almost everyone has heard of pulsars, those strange sources of evenly spaced beeps, or "pulses," of radio waves, which were discovered in 1967. They are interpreted as being highly magnetized, rapidly spinning compact objects—so-called neutron stars. A typical neutron star may be smaller than New York City, yet contain as much matter as our sun and possess a magnetic field stronger than any yet produced in the laboratory. A neutron star can be formed by the collapse of the central core of a massive star in its death throes, during a supernova explosion. As the neutron star spins, it sends radio waves into space in narrow beams that sweep around like the rotating beacon of a lighthouse. When a pulsar beam strikes the earth, we observe a radio pulse. Hence the interval between successive pulses is the rotation period of the neutron star.

As soon as the discovery of pulsars was announced, optical astronomers—myself among them—began to search for visible light flashes from these objects. Many pulsars were examined without success until astronomers at the University of Arizona detected light from the pulsar in the Crab nebula. These optical pulses came from a dim star in the center of the nebula which appears on many photographs and had even been mentioned in 1942 as the possible remnant core of the supernova that produced the nebula. The pulses had never been noticed because they come about 60 times a second (the Crab pulsar has a spin period of 1/30 of a second, but has two nearly equally spaced pulses in each period). Thus, the Crab pulsar is much like a fluorescent light bulb that runs on the normal 60-cycle alternating current: it flashes on and off but so rapidly that to the human eye and brain, and of course on a photographic time exposure, it seems to be a steady source of light. (This doesn't happen with an incandescent bulb because the tungsten filament doesn't have time to cool during the brief instant the alternating current goes to zero.)

The characteristic that distinguished the Crab pulsar from all the others we had unsuccessfully monitored was its rapid pulse period. The others had periods of from about ¼ second to 2 seconds. Radio observations showed that these intervals were gradually lengthening. The effect is almost imperceptible, but over astronomical periods of time, it can change a fast pulsar into a slow one. The spinning neutron stars are slowing down, and theorists suggested that as part of the process they also lose the power to produce visible pulses.

Given the above suggestion, we turned our attention to the second-fastest of the then-known pulsars. This object is PSR 0833-45, the Vela pulsar, named for its location in Vela X, a scattered nebulosity produced in a supernova explosion that occurred some 10,000 to 30,000 years ago. Located deep in the southern sky, PSR 0833-45 is only barely accessible to Northern Hemisphere observatories and hence had been neglected until its special importance as a fast pulsar became apparent in early 1969.

The Arizona group had noted that the light of the Crab pulsar was blue. With this as a clue, they examined photographs of the Vela pulsar region that were made in light of different colors with a 24-inch telescope at the Cerro Tololo Inter-American Observatory in Chile. The available radio measurement of the Vela pulsar position was of limited accuracy; thus it was necessary to study a small box in the sky, surrounding this position, known as the "error rectangle." They found only one notably blue star in the rectangle and reported a tentative "suggestion of faint nebular wisps emanating from the star," but admitted that these were so faint that their nature was uncertain. Nevertheless, they proposed the error rectangle blue star, later named "K," as a likely candidate for the visible-light counterpart of the Vela pulsar. Of course, confirmation would require the detection of optical pulses from the star.

The hunt for the Vela pulsar then went into full swing. In the first quarter of 1969, observations were made by groups at Cerro Tololo and at the McDonald Observatory in Texas, the Mount Stromlo Observatory near Canberra, Australia, and the Radcliffe Telescope in Pretoria, South Africa. Several observers established that the light of star K is

by Stephen P. Maran

not pulsed and that if any optical pulsar was present in the Vela region, its magnitude must be so faint as to be beyond the range of standard observatory atlases, such as the Palomar Observatory Sky Survey.

In March 1969, radio astronomers in Australia and at the Jet Propulsion Laboratory (JPL) in California were astounded to find that the gradually slowing beat of the Vela pulsar had abruptly quickened and then slowed down again. This event, the first known pulsar "glitch," has been attributed to a "starquake," or surface disturbance in the neutron star, although the true cause remains uncertain. In any case, the discovery of glitches was to have a significant implication for subsequent optical searches.

The "hunting season" for the Vela pulsar runs from December to March, as the object is then best placed for optical observation. Accordingly, there were no more searches until December 7, 1969, when a Hale Observatories astrophysicist turned the powerful 200-inch telescope on Palomar Mountain in the direction of Vela. The purpose was to monitor the small error rectangle corresponding to a new determination of the pulsar's radio position, as reported by JPL radio astronomers. The new position was found by analyzing the times at which the radio pulses were received, rather than by mapping the Vela region with the JPL radio telescope. A pulsar position determined in this manner is called a "timing position."

Despite the high reported precision of the new position and its



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consequent small error rectangle, no optical pulses were observed, leading to the conclusion that the pulsar must be no brighter than the 24th magnitude, or at least 100 times fainter than the star K. The Palomar measurements were very difficult to make, since the pulsar is only observable from that location for a short time each night and then only under fine atmospheric conditions near the horizon, where they usually are poor. After this work, the hunt shifted to observatories in the Southern Hemisphere, where Vela is better placed for optical study.

Until 1970, the apparatus used to search for light from the pulsar had as its principal component a photoelectric photometer, a device that measures the intensity of light from only one location at a time. All of the observations had been made with this kind of equipment and all of them had failed. During 1969, I discussed the status of the search with my colleague Hong-Yee Chiu, an authority on neutron stars. We concluded that a new approach was required, one that would enable us to search for the pulsar at a large number of adjacent sky locations simultaneously. In effect, we decided to search an area wider than the reported radio error rectangles, but without requiring an impractical amount of telescope time to study the many individual stars in the region one at a time.

The period between the radio pulses of the Vela pulsar is about 89 milliseconds (thousandths of a second) and the duration of each pulse is only 1/20 of that period. What Chiu and I wanted to do was to take about twenty evenly spaced pictures of the pulsar region during such a period and see if an otherwise invisible star "turned on" during one of the exposures. The difficulty was that such an exposure time (about 4½ milliseconds) is so short that a photograph—even if made with the world's largest telescope—would not record the fainter stars. We had to be able to make a time exposure in which the camera shutter would open once every 89 milliseconds and remain open for just 4½ milliseconds. Further, we needed at least twenty such photographs, each properly phased with respect to the others, so that each interval of 4½ milliseconds within the basic 89-millisecond period

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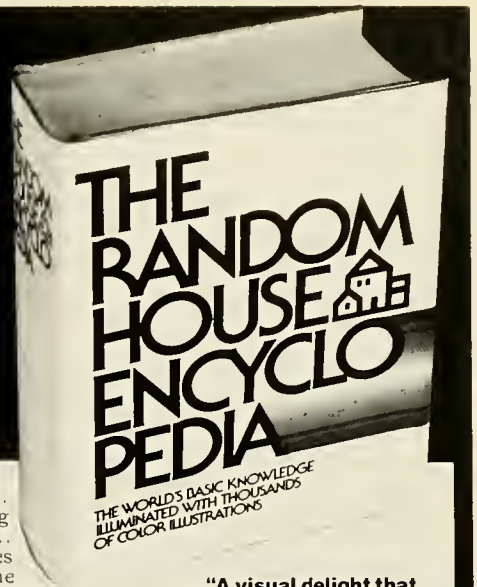
would be covered by a separate time exposure. Then we would be sure to catch the pulsar (if it were bright enough) in one of the pictures. Chiu designed an electromechanical system—the "pulsar hunter"—for this task and we mated the system to an image-intensifier camera developed by Roger Lynds of the Kitt Peak National Observatory in Arizona. This camera converts faint starlight to much brighter green light that can be photographed with a short exposure time.

After successful field tests at Kitt Peak, in which we made a photo sequence showing the Crab pulsar blinking on and off, we took the equipment to Cerro Tololo. There, during four nights in January 1970, we obtained dozens of photographs of the Vela pulsar region with the pulsar hunter mounted on a 60-inch telescope. No star answering to the expected description of the pulsar (flashing on once in each series of about twenty photographs) was found. But one tantalizing starlike object did appear on two pictures in one series. The two exposures were separated by about 8 milliseconds within the pulsar period. The object appeared at the same spot on each of them, but it was not visible on the single exposure that was taken between the two or on any of the other photographs. If this was the Vela pulsar, then it had a double optical pulse, rather than a single one as observed with radio telescopes. We eventually decided that the object was probably caused by a temporary electrical instrument flaw, as it would otherwise have appeared in one of our other photo series.

Our photographs established that the Vela pulsar must be fainter than magnitude 24.8. As a further effort, Lynds took seventy-five of our finest exposures and painstakingly superimposed them to obtain a composite print showing the faintest possible stars. This composite, much better than previous pictures of the Vela pulsar region, showed that the nebular wisps suspected near star K by the Arizona astronomers did not exist. The search had to go on.

In the late summer of 1970, a leading Italian pulsar theorist completed a calculation indicating that the light of the Vela pulsar might be of the 25th magnitude, or slightly fainter than the value our observa-

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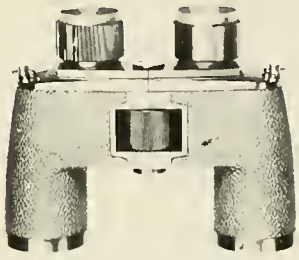
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tions had reached. In May 1971, radio astronomers made new measurements of the positions of nine pulsars with the interferometer radio telescope at the National Radio Astronomy Observatory (NRAO) in Green Bank, West Virginia. In eight cases, they found the positions to be in good agreement with those determined by timing the reception of radio pulses. The single exception was the Vela pulsar. If the NRAO position was correct, then the pulsar was situated outside the timing position error rectangle that the Palomar observer had studied. Chiu and I were therefore right to have studied a larger area with the pulsar hunter even though the pulsar proved too faint for us to record.

In late August 1971, the JPL radio astronomers observed a second glitch in the radio pulses from Vela. This suggested a possible explanation for the discrepancy between the timing and the NRAO positions. Perhaps smaller glitches had occasionally occurred. If unrecognized, they would not be taken into account in the determination of the timing position derived from the arrival times of the radio pulses, and this position would therefore be wrong. On the other hand, critics of the NRAO work pointed out that the pulsar was necessarily observed very close to the horizon at Green Bank, and hence the NRAO measurements might be unreliable.

A star, "C," had appeared on our composite photo near the NRAO position and was the subject of observation by Barry Lasker of the Cerro Tololo staff during the 1972 pulsar season. Using a photometer and the 60-inch telescope, he also surveyed several positions on the south side of the error rectangle corresponding to the NRAO position. However, due to the time-consuming nature of the photometer method, the northern half of the rectangle was neglected. No pulses were detected from C, or from the other observed locations. In retrospect we know that had the survey been extended to the northern part of the rectangle, in all probability the pulsar would have been found.

In February 1973, physicists at the Goddard Space Flight Center discovered gamma rays from the Vela pulsar with an instrument carried on the SAS-2 satellite. Surprisingly, they found that there are two gamma-ray pulses per pulsar period, as contrasted with the single radio pulse. I got out our 1970 observations and studied the apparent double-pulsed star that we had rejected as a pair of instrumental flaws. However, the spacing of the purported optical pulses was quite different from that of the gamma-ray pulses, so I again rejected the optical images.

In the meantime, two University of Sydney scientists had set out to resolve the discrepancy between the timing and the NRAO position for the Vela pulsar. With the aid of a large antenna at the Molonglo Radio Observatory in New South Wales, they determined a supposedly more accurate position, close to a star designated "A" that had been briefly studied at Cerro Tololo. On February 25, 1973, star A was again observed at Cerro Tololo but no evidence of pulsed light was found. The hunt for the Vela pulsar now seemed at a dead end. Three radio observatories had provided positions for the pulsar, each position had been studied by optical astronomers, and no optical pulses had been found. The search was abandoned until early 1975, when a large new reflector, the 4-meter telescope, had been erected at Cerro Tololo and was under test.

As part of the tests, Lasker photographed the Vela pulsar region in three colors of light. A faint blue star termed "M" was found even closer to the Molonglo position than A. Four hours of photometer monitoring of this star with the 60-inch telescope failed to reveal optical pulses. Nevertheless, Lasker proposed M as the latest and best candidate for the Vela pulsar with the suggestion that if its blue light was unpulsed, the light must then correspond to the actual glow of the hot neutron star surface, rather than to the beamed pulses that arise from plasma in the star's magnetic field.

In March 1975, a group of Australian radio astronomers, including one from Sydney, began a new observing program. This time, two large radio telescopes were independently directed at the pulsar, and the results were averaged to get the best possible measurement. By the time this work was completed in the fall of 1976, a 3.9-meter re-

flector telescope was in operation in Australia. In January 1977, an Australian-British team of astronomers led by P. T. Wallace used this telescope and an improved type of photometer to optically search the latest radio position. At four locations in the error rectangle, they monitored the light from a tiny area of the sky, and from two of the areas, which happened to overlap, light pulses from Vela were at long last detected. The Vela pulsar had been optically measured. Star M is in the area of overlap but whether M is the pulsar is not confirmed.

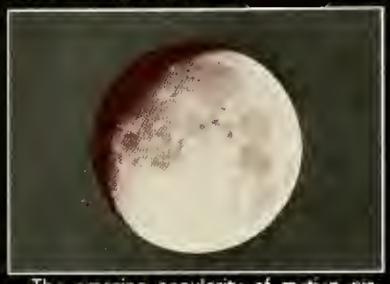
In contrast to the Crab pulsar, which emits simultaneous pulses in the radio, optical, X-ray, and gamma-ray wavelength regions twice in each period, the Vela pulsar has one radio pulse, two optical pulses, and two gamma-ray pulses, but no detectable X-ray pulses. Of the five pulses that it does produce, none are generated simultaneously. The brightness of the pulsar, a time-averaged magnitude of 25, is just what the Italian theorist Franco Pacini had predicted in 1970. Allowing for their respective distances from the earth and correcting for the different amounts of interstellar dust absorption, this means that the true brightness of the Vela pulsar is 20,000 times less than that of the Crab pulsar. Star M, being in the right position, may well be the Vela pulsar, but if so, there is a discrepancy in some of the measurements. Alternatively, the pulsar may be invisible on existing photographs.

Although the brightness of the Vela pulsar was correctly calculated, its second optical pulse and the nonsimultaneity of the pulses in different wavelength regions were not predicted. Formerly, we knew of only one optical pulsar—that in the Crab nebula—and hence felt free to draw analogies from it. Now that we have two optical pulsars with unaccountably different properties, any extrapolations drawn from them are a priori questionable. Once again, a major observational discovery has left us more puzzled than we were before it was achieved.

Stephen P. Maran is senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

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by Raymond Sokolov

As a Matter of Fat . . .

Edible fats and oils are essential to our cuisines

From the window in the place where I work, above the warehouses of Manhattan's commercial meat market, I see a tallow firm's big trucks hauling away loads of fat. In New Jersey, they will dump their white, greasy cargo into vats and heat it to 230°F, until the protein within the fatty mass coagulates and can be strained away (at home, on a smaller scale, Grandma did the same thing, passing around the savory cracklings, little knotted-brown treasures of flavor), leaving the plain fat to be saponified with lye. As soap in scented bars, the suet comes back to town.

On this industrial scale, or in Grandma's traditional hands, fat has a value. But it is a quirk of modern life that fat, which was once a prized part of meat, is now disdained, shunned as poison. The warriors of the *Iliad* barded the sacrificial viands of their "equal feast" with rich envelopes of fat. The author of the first book of Samuel counsels: ". . . to obey is better than sacrifice, and to hearken than the fat of rams [15:22]." But we treat fat as garbage because our sedentary, long lives spent in overheated buildings no longer require the calorific stoking that fat fuels in the body.

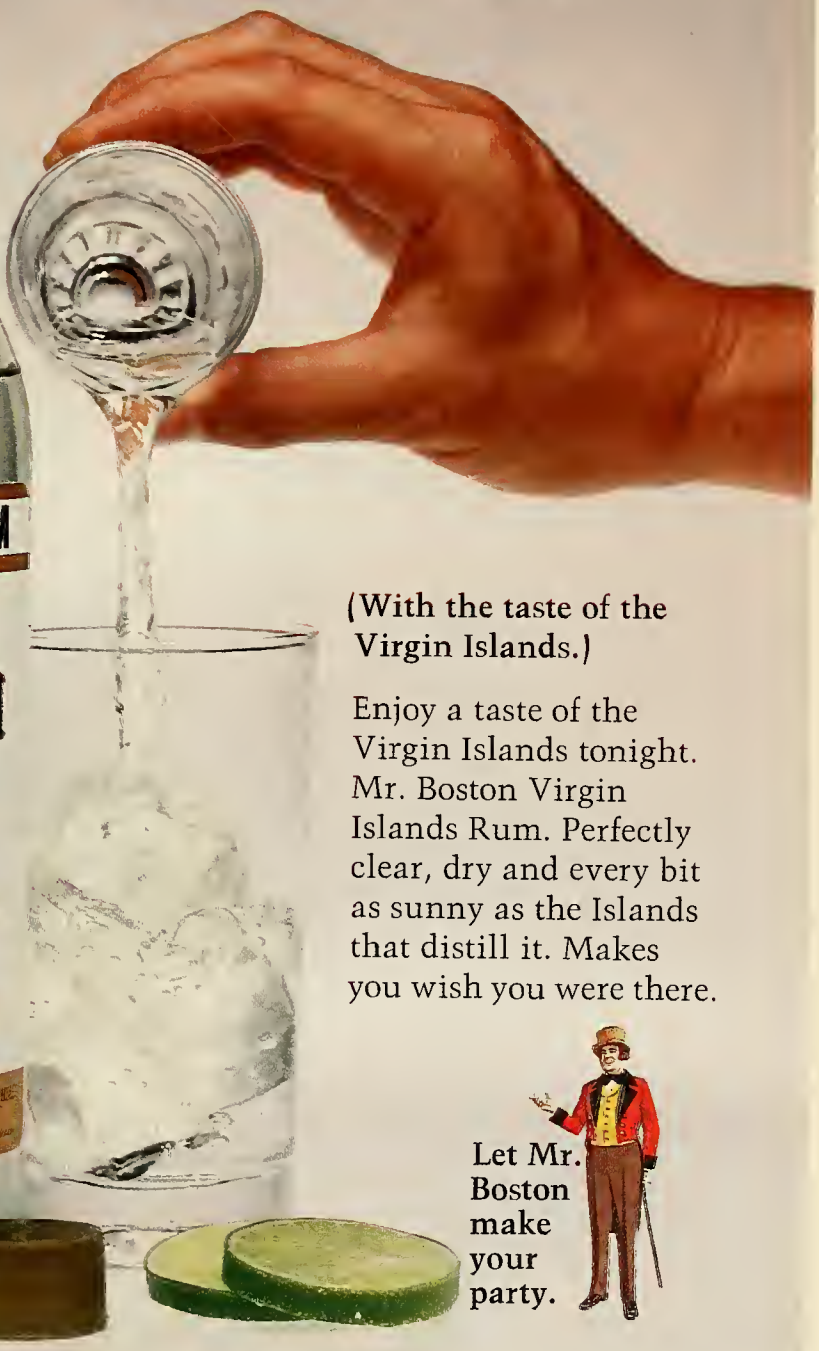
Fat is the ideal source of food energy. With an average potential of 9.3 calories per gram, fat produces roughly twice the energy of proteins or carbohydrates. The body absorbs and stores 94 to 98 percent of ingested fat—under the skin in unglamorous rolls of pudge; some say, in cholesterol plaques on progressively hardening artery walls. The plaques may cause heart attacks (although recent evidence casts doubt on the cholesterol/coronary theory). Obesity certainly strains the heart. In a desk-bound culture, we don't need the energy people once did who chopped wood all winter. Preventive medicine, by prolonging life spans, has also increased the prevalence of degenerative disease, has given the heart time to break down under its burden of adiposity. And so, even if it turns out that low-cholesterol diets do not reduce the accumulation of arterial plaques (as butter lovers learned with pleasure from a report late last year), gobbling fat with abandon will still be a nutritional mistake.

The trouble is that the traditional diet or cuisines we have inherited from the past depend heavily on fats, technically and for their flavor. The fear of frying felt by modern dieters may have a basis in nutritional fact, but our taste buds tell us that food sautéed without butter or oil on nonstick surfaces is insipid. How else can we achieve the crispness of deep-fried potatoes or dumplings or fish if not by "surprising" these foods in the high heat that deep fat conducts? Boiling water will only transmit its maximum temperature of 212°F. But corn oil permits the instantaneous submersion of breaded salmon escalopes into a medium that is uniformly conducting heat at 375°. Done properly, deep-frying does not soak food in fat. On the contrary, appropriately high temperatures seize the outside of the food, brown it, and leave the inside heated—cooked through but never overcooked. This makes deep-frying the optimum method for such delicate foods as fish, which are so easily damaged by slower heating techniques. The amount of oil that permeates correctly fried food, while not negligible, is far less than the sight of a full, working, smoking fryolator at a fast-food counter might suggest.

In contemporary America the overall prejudice against fat has unfortunately subverted taste well beyond the point that dietary caution demands. My children cut away delicious pieces of browned fat at the edge of chops. Chefs, similarly, are turning their backs on roux (flour browned in butter) to thicken sauces. Readers recoil in

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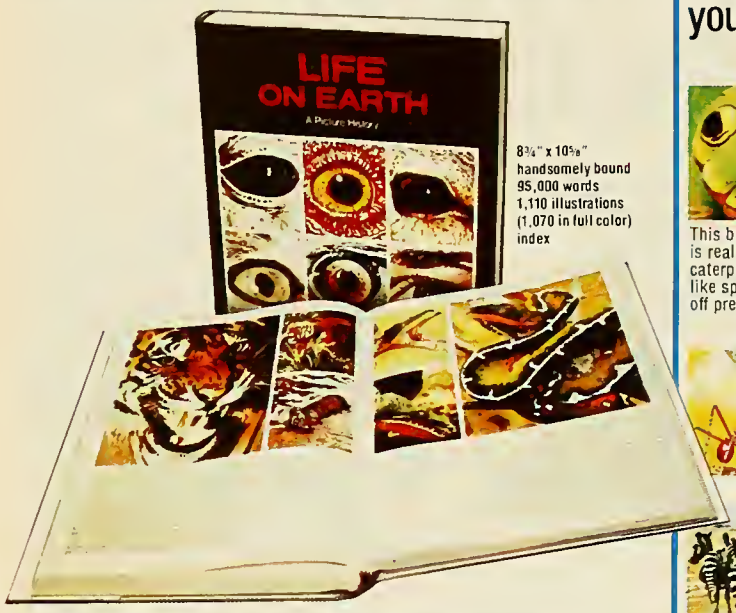
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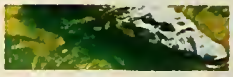
This big-eyed beast is really only a caterpillar, with eye-like spots to scare off predators.



Fish that live in ocean depths are like science fiction creatures—with such features as "glow-in-the-dark" lights, "beards" to help feel their way around, huge teeth to eat other fish since plants are not available.



This ant chews leaves to make "humus"; then uses the humus to grow food in underground "gardens."



Fierce-looking Mississippi alligator, above, is actually shy and will flee from man.





Zebras and ostriches are natural allies and often stay together. Easily-"spooked" ostriches warn zebras of danger; zebras trample grass, flushing insects for ostriches.





Far left: mother racoons will adopt orphaned babies in the area. Left: if a lizard loses its tail, it may grow a new one—or it may grow two or even three by mistake.

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horror from pie crust recipes that use lard, which is not only the traditional American way with pie crusts, but also a superior route to flakiness than butter.

The national antilard bias is part of a generalized aversion to unfamiliar animal fats (and cuts of meat) that has sprung up in a culture utterly divorced from agricultural life and fixated on a very limited number of cattle products. The trend has rapidly led in the last twenty years to the point where hamburger, steak, and butter are practically the only acceptable solid animal foods.

Few children today have ever seen lard or know that it is rendered pork fat. How many adults, even, are aware that suet (once highly prized) is the hard fat from the loins and from around the kidneys of beef cattle? Worse yet, a seemingly authoritative general cookbook published only a few years ago advised junking the delicious fat that tries out of geese and ducks during roasting.

This constriction of knowledge brings with it a narrowing of pleasure. Fats from different sources taste and act differently. I cannot say what Middle Eastern food would taste like if prepared in the ancient manner, with fat from the tails of sheep. But there is no question in my mind that the French were right to call duck and goose fats *les graisses nobles*. To test this, save the drippings from your next duck and use them to make that very unctuous pâté of the Loire region called *rillettes* (recipe below). The fat is the key ingredient, as I was told when I was introduced to this apparently primitive spread at a press conference inside the Paris headquarters of the Banque Rothschild. At the world-famous Troisgros restaurant in Roanne, in France's Beaujolais country, they serve an extremely rarefied thrush pâté also based on duck fat.

In simpler times, the complex individuality of the various fats—their separate identity—was part of life. This vanished diversity is still enshrined in their names, which sprang up separately in languages that usually share cognates. Lard, for instance, may go back to a Greek term for fattened meat, but that meat was not always pork. English speakers must simply have needed a special word for rendered pork fat and fastened on "lard." In France, confusingly, *lard* means fatback or, in the phrase *lard de poitrine*, a version of bacon. When the French want to say "lard," they fall back on a curious and antique word, *saindoux*, which is a combination of *doux* (soft or gentle) and a reflex of the Latin *sagina*, meaning, at various periods: stuffing, food, a fattened animal, and obesity. One authority adds that *sain* once meant the fat of the wild boar.

Meanwhile, in Spain, lard was named *manteca*, on etymological grounds now shrouded in mystery. One thing is clear, lard was once, if it is not still, the preeminent animal fat in the Hispanic world. Lard has given its name to butter: *mantequilla* (butter) is the diminutive of *manteca*.

These are not just linguistic curiosities. The disappearing diversity of fats and oils may indeed have been the most crucial determining factor in the development of traditional cuisines. Waverley Root, in his classic *The Food of France*, divided France into gastronomic sections defined by the particular fat each preferred: butter for the capital region, olive oil for Provence, goose fat for the southwest, and so on. But underneath this fatty pluralism lies an essential unity. Butter, lard, suet, goose fat, duck fat, peanut oil, palm oil, and canned vegetable shortening are all members of one chemical group. Whether they are pressed from seeds or rendered from porcine leaf fat or churned from milk, edible fats and oils are all basically organic chemicals that come about when the acid glycerol is linked with one or more of the so-called fatty acids. This chemical hybrid is a kind of ester called glyceride. In edible fats, the glyceride molecule typically has three long, straight fatty acid chains with even numbers of carbon atoms and is, therefore, a triglyceride. (Monoglycerides and diglycerides are closely related to fats and oils and are used as additives in packaged food products to improve texture and increase shelf life.)

The carbon chains of the fatty acids are bonded on both sides with hydrogen atoms. If all the possible carbon bonds are occupied by hydrogen atoms, the fat is said to be saturated. If one or more of the



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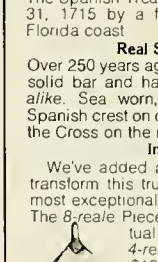
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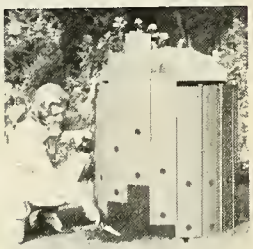
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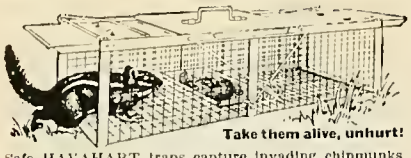
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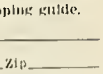
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positions is empty—has no hydrogen atom—then the fat is called unsaturated. Generally speaking, saturated fats are the ones that have been tagged as the villains in the cholesterol theory of heart disease.

Whether this is true or not, the structure of the fatty acid chains does determine the difference between fats and oils. Acids with fewer than 10 carbon atoms or with more than 10 carbon atoms but only one unsaturated hydrogen position are oils, that is, they remain liquid at ordinary temperatures. Fats solidify.

Chemical structure also affects fats' resistance to spoilage. The unsaturated fatty acids are more vulnerable to oxidation. Saturated fatty acids do not oxidize as easily and, therefore, are less subject to the malodorous condition we perceive as rancidity. Natural vitamin E in fats inhibits this process, but heat, light, and contact with copper and iron will all hasten rancidity. Refrigeration ought to have ended this problem for modern shoppers. But erratic, long supply networks sometimes bring spoiled butter to market. You can detect rancidity, even through paper wrapping, if you smell the butter before you buy it.

Once you have the butter home, you can preserve it for weeks at a stretch in a freezer running, as it should, at 0°F. Or you can stabilize butter in the old fashioned way, through clarification. Here, there are two standard methods: one pure and French; the other less refined, more flavorful and Indian. Either one removes the cheesy milk solids that react so easily with bacteria and that burn at a lower temperature than clarified butter.

In the French method, melt butter and let it stand undisturbed for a half hour. By then, the milk solids will have settled. Spoon the clear butter into a clean container.

In the Indian method, which produces a nutty-brown substance called ghee, simply simmer the butter until the milk solids all burn and fall to the bottom of the pan. When the top of the butter has cleared, spoon it into a clean container. It will be much easier to make ghee or to clarify butter in the French manner, if you work with a pound of butter or more at a time. The quantity forestalls burning and also economizes your time. Either ghee or clarified butter can be heated to higher temperatures than regular butter.

Now it is also true that neither ghee nor clarified butter can be heated nearly to the point that peanut and other vegetable oils can attain before they start to smoke and break down. But the taste of food sautéed in butter is incomparable, and that is the point of today's sermon—old-fashioned fats in all their variety broaden the enjoyment of human life. Join me then in a protest against two scientific travesties against fat: the spray-on, tasteless, no-stick butter substitute and, that ultimate betrayal of butterfat, ultra-pasteurized heavy cream, which has had its structural knees broken and will not expand properly when whipped. And while you wait for real cream to come back, enjoy—in moderation—the natural fats that are still around.

Rillettes

- ½ pound rendered duck or goose fat
- 1 pound boned pork shoulder, cut in 1-inch cubes
- 1 pound skinned pork belly, cut in 1-inch cubes
- 1 medium onion, peeled and sliced
- 2 bay leaves
- ½ teaspoon dried thyme
- ½ cup chicken stock
- 1½ teaspoons salt
- ¼ teaspoon black pepper

1. Put all ingredients in a heavy, covered saucepan. Bring to a boil, reduce heat, and simmer slowly for two hours or until meat can be crushed with a fork.
2. Turn out into a metal mixing bowl. Stir vigorously over ice until smooth and spreadable. Serve with crusty bread as an hors d'oeuvre, at room temperature.

Yield: 12 servings

Note: As long as you preserve the basic proportions, you can easily substitute different fats, different cuts of meat (balanced between fat and lean), and different stocks. All-goose *rillettes*, for example, would be a very luxurious preparation.

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.



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Announcements

An exhibit of **Nigerian Artifacts** displaying the role of art in the everyday life of that country's several cultural groups will open in the Museum's Gallery 77 on April 19. Running through May 31 before it begins a nationwide tour, the exhibition consists of more than 150 wood, bronze, and ivory objects from the eighteenth century to the present. This is the first public exhibition in the United States of these artifacts from the collection of Robert Mayo and Lewis Johnson. There is no additional charge for the exhibit.

Birding, both in backyards and on mountaintops, is the subject of a new exhibit at the Museum, **The Sport of Birding.** Opening on April 5 in the Akeley Gallery and continuing through the fall, the exhibit includes films and models of birds, a bird identification quiz, and sections on field guides and equipment.

The Museum will celebrate American Indian life in a **Native American Weekend** on April 8 and 9. From 1:00 to 4:30 P.M. each day, arts and skills of the native American heritage will be demonstrated in the People Center and the Hall of Eastern Woodlands and Plains Indians. Among the topics to be covered are the history of the wampum belt, native American poetry and folklore, and beadwork and porcupine quill work. In addition, two Mohawk Indians will demonstrate the art of weaving birchwood baskets; Rosebud Yellow Robe, a Sioux, will share folklore and oral history; and a variety of films will be presented in the auditorium and the People Center.

Another of the Museum's weekday series, the Tuesday **Slide Lectures** in the People Center, will feature Witchcraft and Sorcery on

April 4, 11, and 18. The slide lecture on April 25 will be on bog plants. The lectures start at 2:00 P.M.

The Spring **Weekend Workshops for Young People** start on Saturday, April 8, and run through May 13. The Saturday workshops are: Exploring Vertebrate Anatomy, Learning Through Drawing, and Exploring with the Microscope; Sunday workshops will be devoted to Nature Photography II. Students must be in grades 5 to 7 (4 to 7 for Exploring with the Microscope). The fee for each course is $20.00. For more information, call (212) 873-7507 or write Department of Education, American Museum of Natural History, Central Park West at 79th St., New York, New York 10024.

Helen Hays, of the Museum's Department of Ornithology and chairwoman of the Great Gull Island Project, will show a film, **Ternwatch,** and give an illustrated lecture on terns on April 12, at 8:00 P.M. in the auditorium. Tickets for Associate Members and the public are $2.00 and will be available at the auditorium door at 7:30. Participating, Donor, and Life Members will be admitted free.

Dancer Judith Janus will present an imaginative multimedia **Members' Program for Children** in the Museum auditorium at 11:00 A.M. on Saturday, April 29, entitled "Bugs, or How to Smell with the Knees, Taste with the Feet, and Wear a Skeleton on the Outside." Accompanied by a series of color slides, Janus will re-create the movements of several insects. The performance is free to Participating, Donor, and Life Members and their children. Admission for Associate Members and the general public will be fifty cents.

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Additional Reading

Carolina Parakeet (p. 10)

Arthur Cleveland Bent's *Life Histories of North American Cuckoos, Goatsuckers, Hummingbirds, and Their Allies, 2 vols.* (New York: Dover Publications, Inc., 1940, $4.00 each in paperback) is a reprint of a United States National Museum Bulletin on birds. Volume 1 has an extensive bibliography and devotes fourteen pages to some of the last field data on Carolina parakeets. Faith McNulty discusses political and ecological reasons why not all endangered animals are saved in *The Whooping Crane* (New York: E. P. Dutton and Company, Inc., 1966). *Birds in Peril: A Guide to the Endangered Birds of the United States and Canada,* by John P. MacKenzie (Boston: Houghton Mifflin Company, 1977), and James C. Greenway's *Extinct and Vanishing Birds of the World* (New York: Dover Publications, Inc., 1967, $5.00 in paperback) are sobering but informative books on currently endangered bird species.

House Mice (p. 38)

Studies of the population biology of house mice, by British scientists motivated by the need to store great quantities of grain during World War II, are the basis for much of Peter Crowcroft's book *Mice All Over* (Chicago: Chicago Zoological Society, 1973). Both this book and his *Life of the Shrew* (London: Max Reinhart, 1957) are amusing, interesting, and scientifically sound. John B. Calhoun of the National Institute of Mental Health used rats and mice to produce models of human behavior under the stress of population density. His "Population Density and Social Pathology" appeared in the February 1962 issue of *Scientific American* (pp. 139–48). J. H. Myers and C. J. Krebs used population statistics in an attempt to relate fluctuations of population, aggressive behavior, and genetic factors in "Population Cycles in Rodents" (*Scientific American,* June 1974, pp. 38–46). "Genetic Variation in Wild House Mice: Where Natural Selection and History Meet," by R. J. Berry (*American Scientist,* January-February 1978, pp. 52–60), discusses genetic variety in wild mouse populations on a Welsh island.

Holy Week in Seville (p. 44)

Two general books on Spain and Spanish values are *People of the Sierra* (2nd edition), by Julian Pitt-Rivers (Chicago: University of Chicago Press, 1972, a $3.45 paperback), and Gerald Brenan's *South from Granada* (New York: Octagon Books, 1976). One of the best anthropological studies of Spanish religious themes is *Person and God in a Spanish Valley*, by William Christian (New York: Academic Press, Inc., 1972). James Michener's *Iberia: Spanish Travels and Reflections* (New York: Fawcett World Library, Crest Books, 1976, $2.50) offers a good overview, but is incorrect in some details. An informative book on Franco Spain, somewhat dated but very enjoyable, is *The Face of Spain*, by Gerald Brenan (New York: Octagon Books, 1976).

Seeds (p. 56)

Nature as Designer: A Botanical Art Study, by Bertel Bager (New York: Van Nostrand Reinhold Company, 1966), and William M. Harlow's *Art Forms from Plant Life* (New York: Dover Publications, Inc., 1974, in paperback) reveal through striking black-and-white photos the elegant geometric forms and structures of plants. *Structure, Form and Movement*, by Heinrich Hertel (New York: Van Nostrand Reinhold Company, 1966), is an illustrated technical work that relates biology and engineering. It covers birds, insects, fruits, and fish, and the chapter on seeds discusses the flight paths of anemochores. A fast-moving work on the functions of plants, with a good bibliography, is *Plant and Planet,* by Anthony Huxley (New York: The Viking Press, Inc., 1975). Amply illustrated, *The Amazing Seeds,* by Ross E. Hutchins (New York: Dodd, Mead and Company, 1965), includes information on size, shape, germination, methods of dispersal, and dormancy of seeds.

Santorini Volcano (p. 70)

The Santorini Volcano and the Desolation of Minoan Crete, by Denys Lionel Page (London: Society for the Promotion of Hellenic Studies, 1970), is a concise study with a good bibliography and many maps and illustrations. Three chapters of Dorothy B. Vitaliano's *Legends of the Earth: Their Geologic Origins* (Bloomington: Indiana University Press, 1973) discuss Santorini. A more scientific work, "Volume and Extent of the Minoan Tephra from Santorini Volcano: New Evidence from Deep-sea Sediment Cores," by N. D. Watkins et al., containing information gathered on the *Trident* research expedition, appeared in the January 12, 1978, issue of *Nature* (pp. 122–26). Two illustrated articles in *National Geographic* are "Thera, Key to the Riddle of Minos" by Spyridon Marinatos (May 1972, pp. 702–726) and "The Isles of Greece: Aegean Birthplace of Western Culture," by Melville Bell Grosvenor (August 1972, pp. 147–93). *The End of Atlantis,* by J. V. Luce (New York: Bantam Books, Inc., 1978), is one of the best books available on the Santorini volcano and its legends. *Volcanoes,* by Peter Francis (New York: Penguin Books, 1976, $4.95), is a general paperback book on the subject.

Katharine D'Agosta



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NATURAL HISTORY

Incorporating Nature Magazine
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May 1978

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Robert G. Goelet, President
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Authors



The conservation of river turtles is the major concern of **Edward O. Moll,** a herpetologist at Eastern Illinois University. Fieldwork has taken him to Mexico, Central America, and most recently, to Malaysia, where he had the support of the New York Zoological Society, the World Wildlife Fund, and the Fauna Preservation Society. This summer he expects to help Malaysia's Fisheries Department develop management plans for river and sea turtles. Moll, who runs in 10,000-meter to marathon-length races, lives in Charleston, Illinois.



G. Causey Whittow became involved in the study of small ungulates during a sabbatical year at the University of Malaya. There he was able to study the smallest ungulate in the world—the lesser mouse deer. A native of Great Britain, Whittow is professor of physiology at the University of Hawaii's School of Medicine and Kewalo Marine Laboratory. His current research deals with the thermal ecology of the Hawaiian monk seal and the basking behavior of the green sea turtle. Whittow's major long-term interest is the biology of tropical sea birds. His last article for *Natural History*, "Night Shift for Sloths and Other Sluggards," appeared in the January 1977 issue.

Colin Turnbull first became interested in prisons and their inmates when he taught anthropology for three years at the Virginia state penitentiary. Turnbull, formerly associate curator of African ethnology at the American Museum of Natural History, is the author of *The Mountain People, The Lonely African,* and *The Forest People,* works that resulted from his African fieldwork. For his article on capital punishment, he visited prisons in Virginia, Georgia, Florida, and California and now envisions a future research project on rehabilitative educational programs in prisons. Born in London and educated at Oxford, Turnbull is at present visiting professor of anthropology at George Washington University.



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"George Edwards was among the first to illustrate various Malagasy lemurs, including the little-known mongoose lemur, which I was interested in studying," writes **Sarah Blaffer Hrdy.** "This led me to search for his books. Once I found them, I fell prey to their charm. It is a dream of mine to see Edwards's work reproduced and once again made generally available." Hrdy, a postdoctoral fellow at Harvard University, is analyzing research gathered from six seasons of fieldwork on Hanuman langurs in India. Her most recent book, *The Langurs of Abu,* was published last year by Harvard University Press.



Edmund Carpenter, anthropologist, film maker, writer, and teacher, is an authority on Indian and Eskimo art and society. Throughout his travels, ranging from the Arctic and Siberia to New Guinea and Micronesia, he has observed the importance of secrecy in the sacred art and music of many native groups. For the past four years, Carpenter has been working at the Museum für Völkerkunde in Basel, Switzerland, on a twenty-volume publication of the unfinished work of the late Carl Schuster, which traces contemporary signs, symbols, and other motifs back to paleolithic cultures. The first nine volumes will appear next year. Carpenter's "Art of the Northwest Coast Indian" appeared in the March 1976 *Natural History.*



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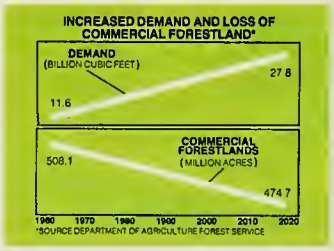
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The idea behind Operation Double Tree is not just to grow more trees faster, but to use more of every tree that is harvested. Harvesting machinery makes it possible. Until recently, these machines were more common in



These two white pines are shown here 92 percent of actual size. Both are 16 years old. The difference is, the small one grew in a crowded thicket, while the large one grew in a field just up the road where the seedlings were planted to give each one plenty of room to grow.

TREE IS WORKING

ther parts of the country, but today they re helping the New England forests yield more efficient harvest.

he Real Revolution.

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The research has already taken ot at companies like Georgia-Pacific, where the superior seedlings are being raised by the hundreds of thousands in greenhouses for planting in harvested areas of Maine.



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by Stephen Jay Gould

Were Dinosaurs Dumb?

Their 100 million years of success belies the common belief

When Muhammad Ali flunked his army intelligence test, he quipped (with a wit that belied his performance on the exam): "I only said I was the greatest; I never said I was the smartest." In our metaphors and fairy tales, size and power are almost always balanced by a want of intelligence. Cunning is the refuge of the little guy. Think of Br'er Rabbit and Br'er Bear; David smiting Goliath with a slingshot; Jack chopping down the beanstalk. Slow wit is the tragic flaw of a giant.

The discovery of dinosaurs in the nineteenth century provided, or so it appeared, a quintessential case for the negative correlation of size and smarts. With their pea brains and giant bodies, dinosaurs became a symbol of lumbering stupidity. Their extinction seemed only to confirm their flawed design.

Dinosaurs were not even granted the usual solace of a giant—great physical prowess. God maintained a discreet silence about the brains of behemoth, but he certainly marveled at its strength: "Lo, now, his strength is in his loins, and his force is in the navel of his belly. He moveth his tail like a cedar. . . . His bones are as strong pieces of brass; his bones are like bars of iron [Job 40:16–18]." Dinosaurs, on the other hand, have usually been reconstructed as slow and clumsy. In the standard illustration, *Brontosaurus* wades in a murky pond be-



Brachiosaurus

Drawings by Gregory S. Paul

cause he cannot hold up his own weight on land.

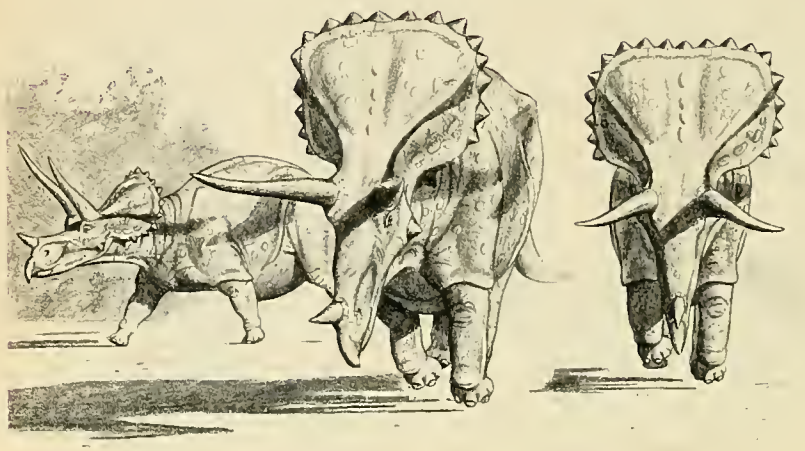
Popularizations for grade school curricula provide a good illustration of prevailing orthodoxy. I happen to have my third grade copy (1948 edition) of Bertha Morris Parker's *Animals of Yesterday*, stolen, I am forced to suppose, from P.S. 26, Queens (sorry Mrs. McInerny). In it, boy (teleported back to the Jurassic) meets brontosaur:

It is huge, and you can tell from the size of its head that it must be stupid. . . . This giant animal moves about very slowly as it eats. No wonder it moves slowly! Its huge feet are very heavy, and its great tail is not easy to pull around. You are not surprised that the thunder lizard likes to stay in the water so that the water will help it hold up its huge body. . . . Giant dinosaurs were once the lords of the earth. Why did they disappear? You can probably guess part of the answer—their bodies were too large for their brains. If their bodies had been smaller, and their brains larger, they might have lived on.

Dinosaurs have been making a strong comeback of late, in this age of "I'm OK, you're OK." Most paleontologists are now willing to view them as energetic, active, and capable animals. The *Brontosaurus* that wallowed in its pond a generation ago is now running on land, while pairs of males have been seen twining their necks about each other in elaborate sexual combat for access to females (much like the neck wrestling of giraffes). Modern anatomical reconstructions indicate strength and agility, and many paleontologists now believe that dinosaurs were warmblooded.

The idea of warmblooded dinosaurs has captured the public imagination and received a torrent of press coverage. Yet another vindication of dinosaurian capability has received very little attention, although I regard it as equally significant. I refer to the issue of stupidity and its correlation with size. The revisionist interpretation, which I support in this column, does not enshrine dinosaurs as paragons of intellect, but it does maintain that they were not small brained after all. They had the "right-sized" brains for reptiles of their body size.

I don't wish to deny that the flattened, minuscule head of large-bodied *Stegosaurus* houses little brain from our subjective, top-heavy perspective, but I do wish to assert that we should not expect more of the beast. First of all (as I wrote in an early column, January 1975), large animals have relatively smaller brains than related, small animals. The correlation of brain size with body size among kindred animals (all reptiles, all mammals, for example) is remarkably regular. As we move from small to large animals, from mice to elephants or small lizards to Komodo dragons, brain size increases, but not as fast as body size. In other words, bodies grow faster than brains, and large animals have low ratios of brain weight to body weight. In fact,



Triceratops

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brains grow only about two-thirds as fast as bodies. Since we have no reason to believe that large animals are consistently stupider than their smaller relatives, we conclude that large animals require relatively less brain to do as well as smaller ones. If we do not recognize this relationship, we are likely to underestimate the mental power of very large animals, dinosaurs in particular.

Second, the relationship between brain and body size is not identical in all groups of vertebrates. All share the same rate of relative decrease in brain size, but small mammals have much larger brains than small reptiles of the same body weight. This discrepancy is maintained at all larger body weights.

· Put these two facts together—all large animals have relatively small brains, and reptiles have much smaller brains than mammals at any common body weight—and what should we expect from a normal, large reptile? The answer, of course, is a brain of very modest size. No living reptile even approaches a middle-sized dinosaur in bulk, so we have no modern standard to serve as a model for dinosaurs.

Fortunately, our imperfect fossil record has for once not severely disappointed us in providing data on fossil brains. Superbly preserved skulls have been found for many species of dinosaurs, and cranial capacities can be measured. (Since brains do not fill craniums in reptiles, some creative, although not unreasonable, manipulation must be applied to estimate brain size from the hole within a skull.) With these data, we have an easy test for the conventional hypothesis of dinosaurian stupidity. We should agree, at the outset, that a reptilian standard is the only proper one—it is surely irrelevant that dinosaurs had smaller brains than people or whales. We have abundant data on the relationship of brain and body size in modern reptiles. Since we know that brains increase two-thirds as fast as bodies as we move from small to large living species, we can extrapolate this rate to dinosaurian sizes and ask whether dinosaur brains match what we would expect of living reptiles if they grew so large.

Harry Jerison (*Evolution of the Brain and Intelligence*, Academic Press, 1973) studied the brain sizes of ten dinosaurs and found that they fell right on the extrapolated reptilian curve. Dinosaurs did not have small brains; they had just the right-sized brains for reptiles of their dimensions. So much for Ms. Parker's explanation of their demise.

Jerison made no attempt to distinguish among various kinds of dinosaurs; ten species distributed over six major groups scarcely provide a proper basis for comparison. Recently, James A. Hopson of the University of Chicago gathered more data and made a remarkable and satisfying discovery (*Annual Review of Ecology and Systematics*, vol. 8, 1977).

Hopson needed a common scale for all dinosaurs. He compared each dinosaur brain with the average reptilian brain we would expect at its body weight. If the dinosaur falls on the standard reptilian curve, its brain receives a value of 1.0 (called an encephalization quotient, or EQ—the ratio of actual brain to expected brain for a standard reptile of the same body weight). Dinosaurs lying above the curve (more brain than expected in a standard reptile of the same body weight) receive values above 1.0, while those below the curve measure less than 1.0.

Hopson found that the major groups of dinosaurs can be ranked by increasing values of average EQ. This ranking corresponds perfectly to inferred speed and agility in locomotion, which, in turn, reflect behavioral complexity in feeding (or avoiding the prospect of becoming a meal oneself). The giant sauropods, *Brontosaurus* and its allies, have the lowest EQ's—0.20 to 0.35. Presumably, they moved fairly slowly and without great maneuverability. They escaped predation by virtue of their bulk alone, much as elephants do today. The armored ankylosaurs and stegosaurs come next with EQ's of 0.52 to 0.56. These animals probably engaged in mostly passive defense, relying upon heavy armor. But the clubbed tail of ankylosaurs and the spiked tail of stegosaurs indicate some active fighting and increased behavioral complexity.

The ceratopsians are next at about 0.7 to 0.9. Hopson remarks: "The larger ceratopsians, with their great horned heads, relied on active defensive strategies and presumably required somewhat greater agility than the tail-weaponed forms, both in fending off predators and in intraspecific combat bouts. The smaller ceratopsians, lacking true horns, would have relied on sensory acuity and speed to escape from predators." The ornithopods (duckbills and their allies) rank as the brainiest herbivores, with EQ's from 0.85 to 1.5. They relied upon "acute senses and relatively fast speeds" to elude carnivores. Flight seems to require more acuity and agility than standing defense. Indeed, among ceratopsians, the small, hornless, and presumably fleeing *Protoceratops* has a higher EQ than the great three-horned *Triceratops*.

Carnivores have higher EQ's than herbivores, as in modern vertebrates. Catching a rapidly moving or stoutly fighting prey demands a good deal more upstairs than plucking the right kind of plant. The giant theropods (*Tyrannosaurus* and its allies) vary from 1.0 to nearly 2.0. Atop the heap, quite appropriately at its small size, rests the little coelurosaur *Stenonychosaurus* with an EQ well above 5.0. Its actively moving quarry, small mammals and birds perhaps, must have posed a greater challenge in discovery and capture than *Triceratops* afforded *Tyrannosaurus*.

I would never want to make a gross claim that brain size equals intelligence or, in this case, behavioral range and agility (I don't know what intelligence means in humans, much less in a group of extinct reptiles). We know that variation in brain size within a species has precious little to do with brain power (humans do equally well with 900 or 2,500 cubic centimeters of brain). But comparison across species, when the differences are large, seems reasonable. I do not regard it as irrelevant to our achievements that we so greatly exceed koala bears—much as I love them—in EQ. This sensible ordering among dinosaurs also indicates that even so coarse a measure as brain size counts for something.

If behavioral complexity is one consequence of mental power, then we might expect to uncover among dinosaurs some signs of social behavior that demand coordination, cohesiveness, and recognition. Indeed we do, and it cannot be acci-

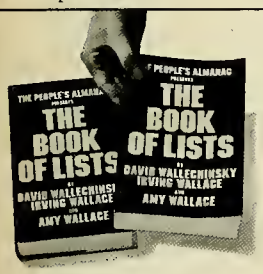
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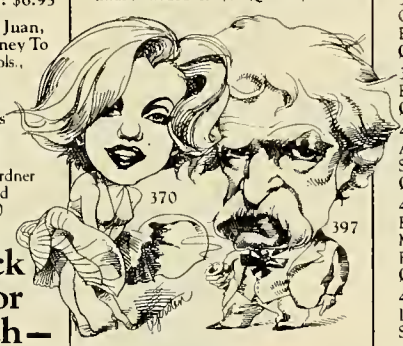
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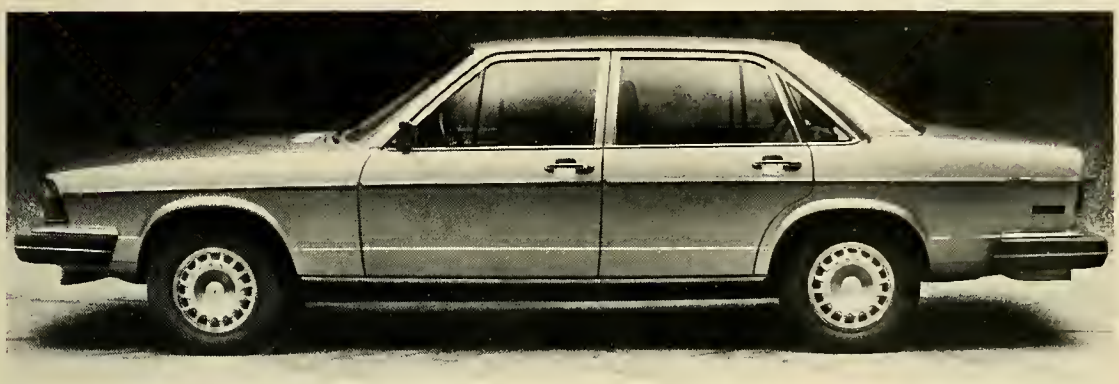
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"I USED TO DESIGN RACING CARS. BUT THE AUDI 5000 WAS A BIGGER CHALLENGE."

AN INTERVIEW WITH FERDINAND PIËCH, AUDI 5000 PROJECT DIRECTOR



Sir, how long did you design racing cars?

Piëch: Ten years in all. I brought six cars from the drawing board to the race track and all six went on to win world championships. It was all very exciting.

And you say designing a passenger car was more of a challenge?

Piëch: It was for me. A racing car can be designed to last for a few races only. But a passenger car obviously has to be designed to do much more and to last much longer. In addition to excellent performance and handling I had to consider things like room, comfort and price.

What about the price?

Piëch: I was determined from the beginning to prove that a large German luxury sedan could be produced for under $9,000.*

Well, you succeeded with price, but did that mean you had to compromise a lot?

Piëch: No. I don't think so. It was a question of eliminating unnecessary things. The greatest example of that is our five-cylinder engine. Five cylinders, because a four was too small for the weight of the car, and a six was too extreme. Designing the perfect engine for the vehicle can hardly be called making a compromise.

Your racing background? Did it come in handy?

Piëch: Yes, yes. Very much so. The way the Audi 5000 handles, for instance. The ride is not in the least bit mushy. Our suspension, our rack-and-pinion steering and our weight distribution have a lot to do with that. Which is why we suggest that people pick a rainy or snowy day to take a test drive. This car is at its best when the weather is at its worst.

Is it possible to build a car with a soft, mushy ride, and still retain great responsive handling?

Piëch: No, not at all. They are exactly opposite. Some people feel that a soft, mushy ride is luxurious. We, the engineers at Audi, do not. We think it's tiring because you seem to be correcting the car's handling so often. We believe that a truly luxurious car is one that does what you want it to do when you want it to do it. That's why we engineered the Audi 5000 to be so precise and responsive.

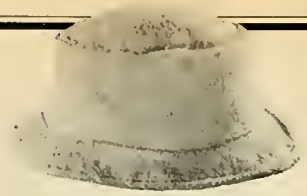
What do you think of American cars?

Piëch: Like everything else, there are good things and bad things. The good things we tried to incorporate in the Audi 5000. More comfort. More room. To be quiet. To give it cruise control as standard equipment. And you can order a powerful, American type air conditioning system for your places like Florida.

Quickly, what would you say to convince Americans to buy an Audi 5000?

Piëch: I would say they can now buy a European car that was designed with American needs in mind. What we have tried to build is the one car that's the best of both worlds. I hope that doesn't sound, ah, what do you say...corny?

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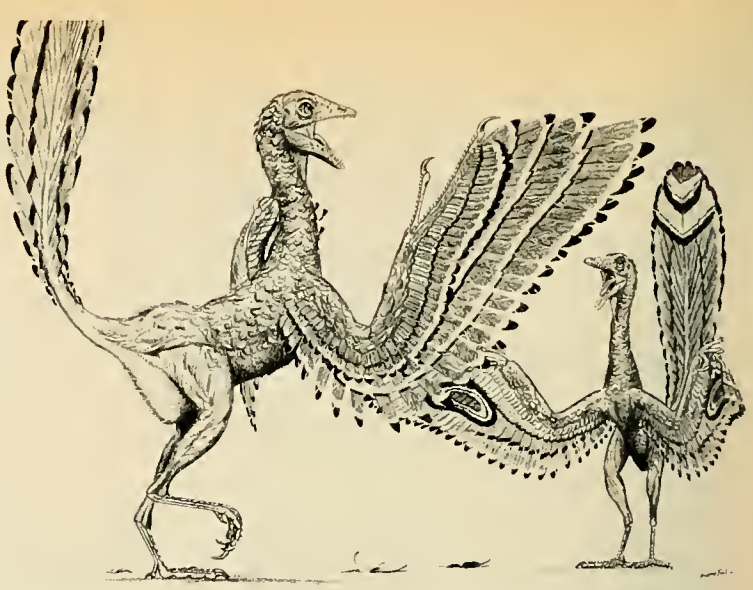
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Archaeopteryx

dental that these signs were overlooked when dinosaurs labored under the burden of a falsely imposed obtuseness. Multiple trackways have been uncovered, with evidence of more than twenty animals traveling together in parallel movement. Did some dinosaurs live in herds? Particularly intriguing is the Davenport Ranch sauropod trackway where small footprints lie in the center and larger ones at the periphery. Could it be that some dinosaurs traveled much as some advanced herbivorous mammals, with large adults at the borders sheltering juveniles in the center?

In addition, the very structures that seemed most bizarre and useless to older paleontologists—the elaborate crests of hadrosaurs, the frills and horns of ceratopsians, and the nine inches of solid bone above the brain of *Pachycephalosaurus*—now appear to gain a coordinated explanation as devices for sexual display and combat. Pachycephalosaurs may have engaged in head-butting contests much as mountain sheep do today. The crests of some hadrosaurs are well designed as resonating chambers; did they engage in bellowing matches? The ceratopsian horn and frill may have acted as sword and shield in the battle for mates. Both for its intrinsic complexity and for the elaborate social system that such behavior implies, we would scarcely anticipate finding it in a group of animals barely muddling through at a moronic level.

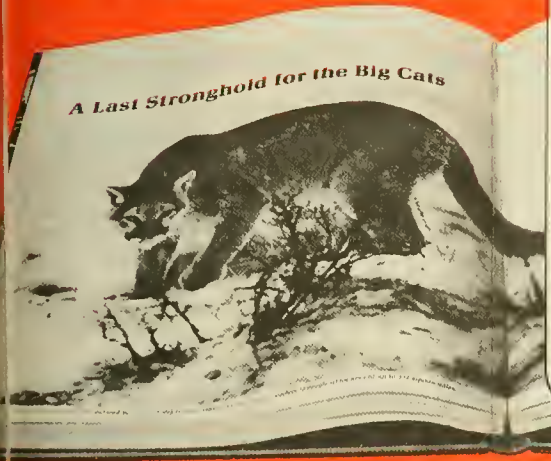
But the best illustration of dinosaurian capability may well be the fact most often cited against them, namely their demise. Extinction, for most people, carries many of the connotations attributed to sex not so long ago—a rather disreputable business, frequent in occurrence but not to anyone's credit and certainly not to be discussed in proper circles. But, like sex, extinction is an ineluctable part of life. It is the ultimate fate of all species, not the lot of the unfortunate and ill-designed. It is no sign of failure.

The remarkable thing about dinosaurs is not that they became extinct, but that they dominated the earth for so long. Dinosaurs held sway for 100 million years while mammals, all the while, lived as small animals in the interstices of their world. After 70 million years on top, we mammals have an excellent track record and good prospects for the future, but we have yet to display the staying power of dinosaurs.

People, on this criterion, are scarcely worth mentioning—5 million years perhaps since *Australopithecus*, a mere 50,000 for our own species, *Homo sapiens*. Try the ultimate test within our system of values: Do you know anyone who would wager a substantial sum, even at favorable odds, on the proposition that *Homo sapiens* will last longer than *Brontosaurus*?

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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by Robert S. Desowitz

On New Guinea Tapeworms and Jewish Grandmothers

Some parasites take fantastic—and tragic—cross-cultural voyages

Even I confess to a certain coolness of heart toward tapeworms. But when the World Health Organization (WHO) calls, all parasites are equals regardless of race or region. And so I found myself in the central highlands of Irian Jaya, Indonesian New Guinea, the WHO consultant sent to advise on the control of a pig-transmitted tapeworm that was sending the Ekari of Enarotali into epileptic convulsions. Once again I was about to learn that in problems of public health, expert but alien reason is usually not reasonable to the peoples of another culture.

To the peoples of New Guinea the pig is more than pork. Throughout the large island, man and pig have a relationship that is intimate beyond domesticity. The pig is a quasi-family member, a source of food, and ultimately a gift to propitiate the spirit world. The great, gory festivals during which great numbers of pigs are consumed are held to gain prestige, to pay off obligations, or to celebrate a successful battle.

At other times the pig is in constant demand for ritual slaughter. One or more must be killed at the birth of a child or in any unfortunate circumstance or other perceived emergency requiring sacrifice to gods and ancestor spirits. Ritual slaughter represents something more than paying the premium for the insurance of spiritual good will; it reflects the absolute belief that life and sanity require harmony with the spirit world. Pig sacrifice is a major means of attaining that harmony. Thus, the introduction of the pig tapeworm, *Taenia solium*, into New Guinea was both a medical and cultural disaster.

Pig and man share not only more habits than we like to admit but also two helminth parasites, the nematode *Trichinella spiralis*, the cause of trichinosis, and the tapeworm *Taenia solium*. Trichinosis, once a common infection in the United States, can be an unpleasant, even fatal, disease but the tapeworm is the villain of this piece.

Tapeworms belong to the class Cestoidea, gutless flatworms that absorb nutriment directly through the integument. In a sense a tapeworm is a communal chain of individuals that keep in touch by means of common lateral nerve cords. Each mature segment in the chain comes complete with male and female sexual organs and an excretory pore to dispose of metabolic wastes.

The "head" of the tapeworm, a segment referred to as a scolex, has specialized structures, or suckers, augmented in some species with hooks, to anchor the worm to the host's intestinal wall. The scolex is also the germinal center from which all other segments of the tape arise. Near the scolex the segments are sexually immature; in the middle of the chain they are sexually functional; and at the terminal portion, gravid—mere sacs of eggs. The gravid segments separate and either disrupt and release their eggs inside the bowel or are passed whole with the feces.

To develop completely, tapeworms require one or more intermediate hosts. When a pig swallows the egg of a *Taenia* tapeworm, the egg hatches within the pig's intestine but the worm does not develop to the adult "tape." Instead, the microscopic embryo penetrates the intestinal wall and enters a small vein. Circulating blood carries the embryo to various parts of the pig where it will develop into a cysticercus, a bladderlike form with an invaginated structure that will eventually become the scolex. The tapeworm develops no further until a human ingests pork containing the cysticercus. Now safe in its final home, the scolex pops out, attaches to the human intestinal wall, and the worm begins to grow to its full complement of segments.

Most adult tapeworms have a strict host-specific relationship; only man can serve as definitive host (the host for the sexually mature stage) of *Taenia solium* and its close relative *Taenia saginata*. *Taenia solium* is known as the pig tapeworm and *Taenia saginata* as the beef tapeworm because the cysticerci are found in those animals.

Transmission of the disease occurs when infected humans defecate where cows or pigs feed. The animals ingest the eggs, which develop into cysticerci; and the cycle is completed when humans eat undercooked pork or a tasty steak tartare. One highly important differ-



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ence between the pig tapeworm and the beef tapeworm is that humans can also act as intermediate hosts for the pig tapeworm. If a person swallows an egg of the beef tapeworm, the worm embryo would die in that unsuitable host. But when a human ingests an egg of the pig tapeworm, the bladder stage of the parasite can develop into a disease known as cysticercosis.

While the harboring of a twenty-foot tapeworm may not be a pleasure (except perhaps that you could refer to yourself in the imperial style as "We"), most infections cause little discomfort. Those harboring a tapeworm are often unaware of the beast within, unless they notice segments in their stools.

It is not worms, but the cysticercus that can be devastatingly pathogenic. After hatching from the egg and entering the blood system, the embryo frequently flows to the brain where it grows into the bladder form. In time, an inflammatory reaction can lead to such neurological disorders as epileptic-like convulsions and bizarre personality changes mimicking psychosis. These pathogenic manifestations often do not appear until two to five years after a person has contracted the infection. The condition is like a time bomb inexorably ticking away in the brain.

In 1971, two physicians at the small Enarotali general hospital reported a bewildering "epidemic" of severe burn cases among the Ekari. Some of the twenty-five to thirty cases each month were so bad that limbs had to be amputated. All patients gave similar accounts. While sleeping, they had been overcome by an epileptic seizure and had fallen unconscious into the household fire.

Enarotali is piercingly cold at night. The village sits on the shore of one of the Paniai (Wissel) lakes at an altitude of 5,000 feet, surrounded by the wild barricade of the east-central mountain range. Hardly overdressed for this climate, the local Ekari men wear only a long gourd penis sheath and the women a brief string girdle. To ward off the night chill, they build a fire in the center of rude thatch huts and sleep on bunks around the fire.

The hospital staff had treated burn accidents before 1971 but never on this scale. The frequency of epileptiform attacks was also new, giving rise to the suspicion that some new infectious agent had been introduced.

The pathogen came to light during a survey for intestinal parasites by a team of scientists from the Department of Parasitology of the University of Indonesia School of Medicine in Jakarta. Along with the usual intestinal zoo, they were astonished to find that 8 percent of the fecal samples were positive for the eggs of the tapeworm *Taenia*. Although many parasitological surveys had been carried out in New Guinea for many years, this finding was the first instance of taeniasis. Moreover, the technique of microscopic examination of fecal specimens has a low diagnostic sensitivity for this parasite. Undoubtedly, many more cases existed. For example, in one African study 6 percent of the stools showed taeniasis, while autopsy examinations indicated that more than 60 percent of the population had the tapeworm.

Subsequent clinical examinations of the Ekari revealed cysts under the skin, a sign of heavy, disseminated cysticercosis, and the discovery of the deadly, pearly globules of the cysticerci studded in the brain of a patient who had died of the disease confirmed the cause of the neurological syndrome. Serological tests recently performed by my Indonesian colleagues and me indicate that, at present, at least 25 percent of the Ekari adults and children have cysticercosis.

But where did the parasite come from? How was it introduced into such a remote, isolated area? Reconstruction of historical events indicates that the tapeworm came unseen, riding the anticolonial wave; the vehicles of transport were men and pigs.

In 1969 the United Nations directed the peoples of West New Guinea to choose whether to join the Republic of Indonesia. The Ekari were uncertain, to say the least, about the change in regime, and during the plebiscite, or shortly thereafter, the Indonesians sent troops to Enarotali to help the vote along. Some of the soldiers came from Bali. Indonesia's President Suharto softened the military action by sending a gift of pigs. The pigs came from Bali, since pig rearing in mostly Muslim Indonesia is largely concentrated on the Hindu island.

Whatever the political and social advantages of the gift, the medical results were an unforeseen tragedy. The pig tapeworm has been endemic in Bali for at least 60 years. A favorite Balinese dish is an undercooked pork preparation in which the cysticerci are cleverly disguised by the legendary spices of the Indies. However, the Balinese are fastidiously clean in their personal habits and so while the tapeworm infection is prevalent, cysticercosis is almost nonexistent. In contrast, the Ekari have Stone Age toilet habits and when the tapeworm came from Bali, they became infected via meat and human feces.

Transcultural tapeworm traffic hasn't been confined to Bali–New Guinea and I should like to digress for a moment to recount a somewhat similar occurrence much closer to home. Now that it is epidemiological history, the story is rather amusing. It might be entitled "A Tapeworm Tale of Two Cities," with a cast of characters that includes the fish tapeworm, Scandinavian fishermen, and Jewish grandmothers of New York City.

The fish tapeworm is big, up to forty-five feet in length, and its name, *Diphyllobothrium latum,* fits its size. The historical endemic focus of *D. latum* is Scandinavia, where the infected fishermen defecate in the lakes. The first intermediate host, a copepod, eats the eggs. A freshwater fish, the second intermediate host, eats the copepod. A wormlike larva develops in the muscles of the fish, and humans become infected by eating a Nordic version of sashimi.

When Scandinavian fishermen came to the United States during the nineteenth-century wave of immigration, many settled in the lake region of Minnesota and Wisconsin where they began to ply their trade (and habits). Shortly thereafter the fish in these lakes became infected.

Commerce in live fish took place regularly between the Midwest and New York City at least until the late 1930s. I recall that during my boyhood in New York almost every market had a large holding tank full of live pike, pickerel, and carp. The chief customers were Jewish housewives who magically transformed the fish into an ethnically ambrosial concoction called gefilte fish.

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Basically, gefilte fish is an amalgam of minced fish, pressed into balls, and boiled until done. "Until done" is the tricky part. The grandmothers of that time, to whom the thermometer was considered high technology, would sample the fish until it was cooked just right. The early samples were still quite raw and if infected, contained a viable larval worm. In this way, several of the nice old ladies of Gotham unwittingly acquired a forty-foot Scandinavian immigrant in their digestive tracts. The introduction of fish inspection, sanitary practices, and thermometers, along with the gradual demise of the traditional Jewish grandmother's instinctive culinary arts have made *D. latum* infections rare in the United States.

But to return from New York to highland New Guinea. By 1973 the main epidemiological factors governing the transmission of tapeworm disease were known, but the problem of control remained. In technically advanced countries, refrigerating the pork for the proper length of time kills the cysticerci. Although this is impossible in primitive Enarotali, an effective method would be to cook the carcass thoroughly. Unfortunately, the traditional Ekari barbecue doesn't allow for this. The Ekari throw the dead pig on the fire just long enough to warm it up. One reason for this hasty cooking is that, except for the big feasts, when an Ekari knobbles a pig, he wants it to be all his. Neighbors are not customarily invited for dinner. The Ekari kills his pig secretly—or as secretly as a pig can be butchered—in the dead of night, following the kill with a quick turn on the fire. A fast-food meal takes place in stealth and gloom. (This and other traits have not endeared the Ekari to anthropologists who have described them as greedy, avaricious, and "primitive capitalists.")

The affliction of cysticercosis would seem a compelling enough reason for a change in cooking practice. With incontestable logic, the health educator from Jakarta, a dedicated woman trained at one of America's more prestigious schools of public health, tried to teach the new methods with all the zeal of a Cordon Bleu instructor. So there we were, the educator educating, the doctor expounding on the virtues of sanitation, and the Ekari

nodding in pleasant agreement. After all, under the circumstances, who in his right mind could reject this appeal to common sense? Then one night it all fell apart and the cultural gap yawned into an abysmal chasm.

I was sitting by the fire drinking wine with the village elders. Through the translator, the chief expressed his bitterness that the disease introduced by foreigners had corrupted the tribe's pigs and religion. Then came the real shocker for me when he said: "We are not blind. We can see the seeds that give us the illness in the pig flesh. But no one lives forever and if we must die, then we must die. Life is no longer of pleasure. We are only half men. The Indonesians will not let us make the warfare that gave us manhood. I no longer care if I eat the corrupt pig flesh.

"Even if this were not so, we still could not do as you say. You tell us not to eat the infected pig, to be careful, to cook it long. How can we do this? If a child is born at night we must sacrifice a pig immediately, there is no time to look and see if it has the seeds. The pig must be killed and eaten at once.

"When the missionaries brought us the coughing sickness many years ago [a pertussis epidemic in 1956], we rose in anger. This time we have no heart to do so."

After he concluded, the wine was passed around again. I couldn't remember ever feeling so lonely and helpless.

After I left Enarotali I flew to Jayapura, the provincial capital, to discuss the situation with the governor. He was highly sympathetic and concerned, particularly since we had clear evidence that the infection had now spread to many parts of Irian Jaya. After going over the possible remedies and the difficulty in implementing them, he remarked, as I was about to leave the governor's mansion, "You know they are not like you and me. They are very primitive and it is extremely difficult to change their customs even for their better health." I was about to agree when I noticed that we were both smoking cigarettes.

Robert S. Desowitz teaches tropical medicine at the University of Hawaii.

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ONE OF THESE CAMERAS WAS MADE JUST FOR YOU. HERE'S HOW TO TELL WHICH ONE.

If you've considered buying a 35mm single lens reflex camera, you may have wondered how to find the right one out of the bewildering array of models and features available.

And you have good reason to wonder, since the camera you choose will have a lot to do with how creative and rewarding your photography will be.

Of course, what you pay for your camera is important. But it shouldn't be your only consideration, especially since there are very expensive cameras that won't give you some of the features you really need. So before you think about price, ask yourself how you'll be using the camera and what kind of pictures you'll be taking. Your answers could save a lot of money.

How automatic should your camera be?

Basically, there are two kinds of automatic 35mm SLR's. Both make use of advanced electronics to give you perfectly exposed pictures with point, focus and shoot simplicity. The difference is in the kind of creative control you get.

For landscapes, still lifes, portraits and the like, you'll want an *aperture-priority* camera. It lets *you* set the lens opening, while *it* sets the shutter speed automatically.

This way, you control depth-of-field. That's the area of sharpness in front of and behind your subject. Many professional photographers believe that depth-of-field is the single most important factor in creative photography.

At times you may want to control the motion of your subject for creative effect. You can do this with an aperture-priority camera by changing the lens opening until the camera sets the shutter speed necessary to freeze or blur a moving subject. Or you can use a *shutter-priority* camera, on which you set the shutter speed first and the camera sets the lens opening automatically.

Minolta makes both types of automatic camera. The Minolta XG-7 is moderately priced and offers aperture-priority automation, plus fully manual control. The Minolta XD-11 is somewhat more expensive, but it's the world's only 35mm SLR with both aperture and shutter-priority automation, plus full manual. The XD-11 is so advanced that during shutter-priority operation it will actually make exposure corrections that you fail to make.



Minolta makes all kinds of 35mm SLR's, so our main concern is that you get exactly the right camera for your needs. Whether that means the Minolta XD-11, the most advanced camera in the world. Or the easy-to-use and moderately priced Minolta XG-7. Or the very economical Minolta SR-T cameras.

Do you really need an automatic camera?

Without a doubt, automation makes fine photography easier. But if you're willing to do some of the work yourself, you can save a lot of money and get pictures that are every bit as good.

In this case, you might consider a Minolta SR-T. These are semi-automatic cameras. They have built-in, through-the-lens metering systems that tell you exactly how to set the lens and shutter for perfect exposure. You just align two indicators in the viewfinder.

What should you expect when you look into the camera's viewfinder?

The finder should, of course, give you a clear, bright view of



Automatic sequence photography is easy when you combine a Minolta XD-11 or XG-7 with optional Auto Winder and Electroflash 200X.

Specifications subject to change without notice.

your subject. Not just in the center, but even along the edges and in the corners. All Minolta SLR's have extraordinarily bright finders, so that composing and focusing are effortless, even in dim light. And with a Minolta there's never a question about focusing. You'll find focusing aids in every Minolta viewfinder that make it easy to take critically sharp pictures.

Information is another thing you can expect to find in a well-designed viewfinder. Minolta believes that you should never have to look away from the finder in order to make camera adjustments. So everything you need to know for a perfect picture is right there in a Minolta finder.

In the Minolta XD-11 and XG-7, red light-emitting diodes tell you what lens opening or shutter speed is being set automatically and warn against under or over-exposure. In Minolta SR-T cameras, there are two pointers which come together as you adjust the lens and shutter for correct exposure.

Do you need an auto winder?

If you like the idea of sequence photography, or simply want the luxury of power assisted film advancing, an auto winder may be for you. Minolta auto winders will advance one picture at a time, or continuously at about two pictures per second. And they give you advantages not found in others, like up to 50% more pictures with a set of batteries and easy attachment to the camera without removing any caps. Optional auto winders are available for both the Minolta XD-11 and XG-7, but not for Minolta SR-T cameras.

How about electronic flash?

An automatic electronic flash can be combined with any Minolta SLR for easy, just about foolproof indoor photography without the bother of flashbulbs. For the XD-11 and XG-7, Minolta makes the Auto Electroflash 200X. It sets itself automatically for correct flash exposure, and it sets the camera automatically for use with flash. An LED in the viewfinder tells when the 200X is ready to fire. Most unusual: the Auto Electroflash 200X can fire continuously in perfect synchronization with Minolta auto winders. Imagine being able to take a sequence of 36 flash pictures without ever taking your finger off the button.

You should be comfortable with your camera.

The way a camera feels in your hands and responds to your commands can make a big difference in the way you take pictures.



The match-needle viewfinder: just align two indicators for correct exposure. Because you're doing some of the work, you can save some money.



The electronic viewfinder: light emitting diodes tell you what the camera is doing automatically to give you correct exposure.

The Minolta XD-11 and XG-7, for instance, are compact, but not cramped. Lightweight, but with a solid feeling of quality. Controls are oversized and positioned so that your fingers fall naturally into place. And the electronically controlled shutters in these advanced automatic cameras are incredibly smooth and quiet.

Minolta SR-T's give you the heft and weight of a slightly larger camera, but with no sacrifice in handling convenience. As in all Minolta SLR's, "human engineering" insures smooth, effortless operation.

Are extra features important?

If you're going to use them, there are a lot of extras that can make your photography more creative and convenient. Depending on the Minolta model you choose, you can select from a number of special features. For instance, some models let you take multiple exposures with pushbutton ease (even with an auto winder). Other available extras include a window to show that film is advancing properly, a handy memo holder that holds the end of a film box to remind you of what film you're using, and a self-timer that delays the release of the shutter so you can get into your own pictures.

What about the lens system?

Just about every 35mm SLR has a lens "system." But it's important to know what the system contains. It should be big enough to satisfy your needs, not only today, but five years from today.

There are almost 40 interchangeable lenses available for Minolta SLR's, ranging from 7.5mm fisheye to 1600mm super-telephoto, including macro and zoom lenses and the smallest 500mm lens in the world. And since interchangeable lenses should be easy to change, the patented Minolta bayonet mount lets you remove or attach them with less than a quarter turn.

What's next?

After you've thought about how you'll be using your camera, ask your photo dealer to let you try a Minolta. Handle the camera for yourself. Examine its features and the way Minolta has paid close attention to even the smallest details. And by all means, compare it with other cameras in its price range. You'll soon see why more Americans buy Minolta than any other brand of SLR. For literature, write Minolta Corporation, 101 Williams Dr., Ramsey, N.J. 07446.

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by William K. Hartmann

End of a Small Wonder

The seventeen-year rise and fall of a volcanic crater field in Hawaii

The world is full of age-old geologic wonders that have been turned into natural parks and are visited and enjoyed by droves of sightseers. Less familiar are young geologic features that have comparable interest, but form and then vanish in a matter of decades. Such a place is Kapoho, a small village at the easternmost tip of the island of Hawaii.

On January 13, 1960, a volcanic eruption began near Kapoho along a fissure extending northeast from the Hawaii Volcanoes National Park. As lava flowed toward the village, its 287 inhabitants were evacuated. On January 28, the lava entered the village. The houses of lightweight wooden construction, all that is needed in the mild Hawaiian climate, burned to the ground. Only tangled metal sheeting from the corrugated iron roofs remained among the volcanic cinders. The lava flows reached the shore about a mile away and destroyed the beach homes there before splashing into the sea. By the time the eruption ended on February 6, lava had covered 1,925 acres, of which 400 were new land added to the island of Hawaii.

The last stages of the eruption built a large cinder cone, 420 feet high, later named Puu Laimana. This cone ejected a vast quantity of cinders, which blanketed more than 55 acres to a depth greater than five feet and created a strange panorama resembling a gray snowscape. The final phase of the eruption threw out showers of lava blocks, including pieces a few feet across. These chunks shot high into the air, then thundered down on the cinder field, leaving a landscape pocked with impact craters, each surrounded by a raised rim of displaced cinders. Except for the blue Hawaiian sky, the low scudding clouds, and the distant horizon of green foliage undamaged by the volcanic fireworks, the tableau looked like a scene on the moon.

In the early sixties, as United States scientists studied the lunar surface in preparation for our first manned landings, the similarity of Kapoho to the moon did not go unnoticed. In 1964, as part of the preparation, the first close-ups of the moon were obtained by a Ranger spacecraft carrying television cameras. The last photographs transmitted before the unmanned spacecraft crash-landed revealed a lunar landscape of rolling craters and occasional rocks. The late Gerard Kuiper, an astronomer at the University of Arizona and an experimenter on the Ranger team, analyzed these photographs of the moon's crater field and noted the resemblance to the Kapoho crater field. He subsequently became interested in the Kapoho site and utilized the Kapoho photographs in some of his lunar reports to NASA.

Kuiper believed that most of the relatively small lunar craters (from about five to fifty feet or more in diameter) resulted from the collapse of granular soil and cinders into subsurface cavities in lava flows. Other scientists, however, believed that these small depressions, called secondary craters, resulted from the low-speed impact of debris thrown out of larger craters that had been caused by the crash of meteorites. This latter theory has apparently been confirmed by data from the Apollo flights. The Kapoho crater field, in spite of being fundamentally volcanic, has almost exactly the same properties as those hypothesized for the secondary impact craters formed in the loose lunar dust. For this reason, in 1967 I made the first of several visits to the Kapoho site to pursue my lunar research with Kuiper.

The whole region was dotted with shallow, flat-floored craters from about a foot and a half to five feet in diameter. Lying in many of these depressions were the irregular lava rocks that had produced them. Other craters contained no visible rocks, but excavation uncovered buried rocks. This established that these craters had been formed by the impact of lava fragments. In addition, I found a few examples of another type of crater with a conical floor. These proved to be drainage craters, that is, features formed by the hourglasslike seepage of surface cinders into cavities in the underlying lava flow—in conformance with Kuiper's theory of lunar craters. So Kapoho was a test-bed for both crater theories. But the basic cause of the similarity between the lunar and Kapoho craters was that, in both instances, a layer of granular soil had been bombarded by flying rock debris.

When I returned to the Kapoho crater field in 1968, I found it was changing to a nonlunar appearance. Whereas formerly the field was a cindery gray, by 1968 the craters had developed mysterious ringlike white markings on their rims. The whole area looked like a series of thin white doughnuts. Apparently, moisture caught in the soil during rainfall percolated back up to the crater surface during dry periods. The moisture contained

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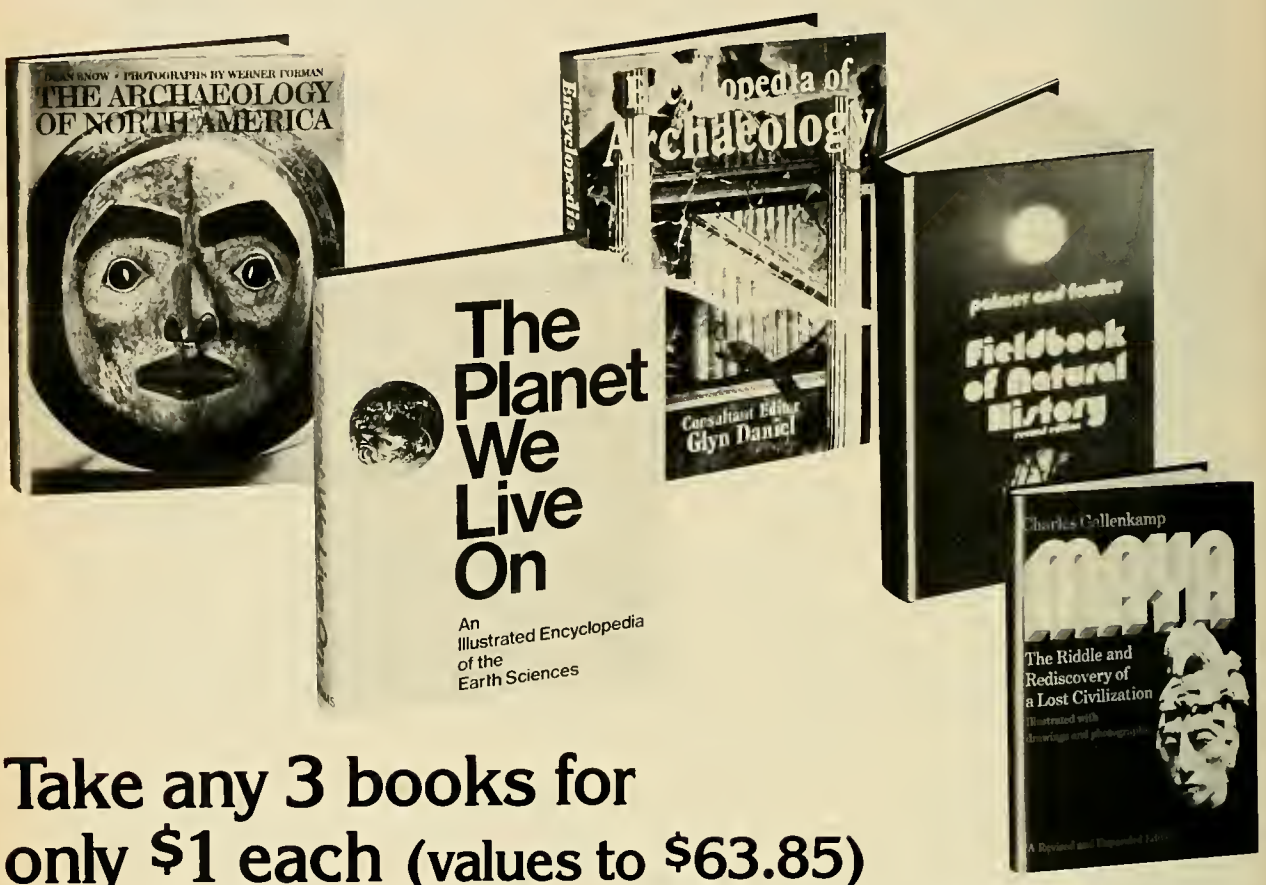
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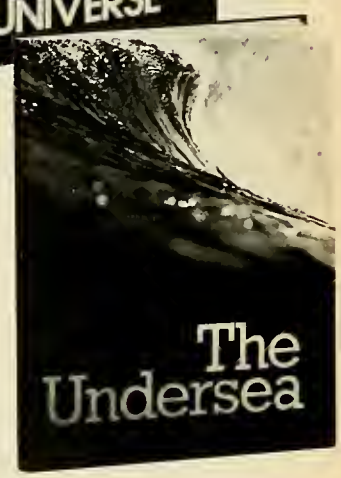
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William K. Hartmann



Ferns grow around a volcanic rock in a Hawaiian cinder field. The craters that once existed here have been obliterated.

salts and other materials in solution, which were deposited in the process of evaporation. Since the evaporation rate was greatest on the raised crater rims, deposits of light-colored evaporites built up in those spots.

Still another, but probably related, surprise came in 1968 when I found grasses were growing in the evaporite rings marking the crater rims. One might have predicted that plants would spring up in the crater centers, where water would be likely to collect—a situation often found in desert craters. But here, rings of grass had sprouted in the cinders of the lava rims. Perhaps there was too much water in the crater centers. Or perhaps the evaporites or the water-flow rates on the rims provided a more favorable environment.

The development of vegetation in the cinder fields continued into the seventies, with plants taking root in all sorts of microenvironments. Clusters of flowering plants grew in pockets of rich volcanic soil, and ferns peeked out from under some of the large lava boulders. On the outskirts of the cinder field, professional orchid growers took advantage of the new soil to cultivate beds of flowers.

Over the years, as water and volcanic gases passed upward through the cinders, leaving behind colored residues of evaporites and sublimates, many parts of the surface of the Kapoho crater field became bonded into a crusty orangish layer. As if keeping pace with space exploration, Kapoho was being transformed into an analogue of another extraterrestrial object—the red planet. This was later confirmed by Viking photographs taken on the surface of Mars, which showed that its dusty soil is marked by crustlike flaky material at the surface. Many scientists believe that this thin, so-called duracrust is the result of the cementing of Martian dust particles by sulfates and other materials deposited when moisture evaporated from the Martian soil. There is no known surface water in liquid form on Mars. But there is presumed to be a small amount of water in other forms and other places—locked in the Martian rocks and as ice under the soil. Current evidence indicates that this limited supply may vaporize from the soil into the air and be transported back again during day–night cycles, forming the Martian duracrust layers in the process.

In the mid-seventies, there were disturbing rumors of one more change at Kapoho. The crater field was being destroyed. I had known about the orchid beds planted on the fringes of the cinder area and was aware that some cinder and ash quarrying had been done, but these activities took place too far from the central crater area to have caused any damage.

During a quick stopover in 1975 I was therefore astonished to discover that although the cinder field seemed to have the same general contours as before, the craters were almost invisible. Only about a dozen could be seen instead of the former hundreds. A few motorcycle tracks aroused my suspicion. Could motorcyclists have wiped out the craters that had formerly covered several acres of cinders?

A more extended visit in 1977 convinced me that this is exactly what had happened. Motorcycle tracks now etch one side of the cone where a crater field had been prominent. Another side of the cone has been transformed into a race track delineated by a set of old tires and completely furrowed by wheel marks. Late-afternoon lighting, which had once revealed a lunarlike landscape, now shows only the grooves of tire tracks. A geologist colleague who visited the area in November 1977 told me that he climbed to the summit of the Kapoho cone and could find no portion of the entire crater field left unscarred by motorcycles.

The Kapoho landscape, with its unearthly craters, ghostly rusting building roofs, and unpredicted natural changes, was a fascinating place to visit from year to year. It was almost completely ignored by tourists driving by on an adjacent highway, including those interested in natural history, yet it was of value. I mourn its passing.

What lessons, if any, can be drawn from Kapoho's fate? First, the world is full of small-scale natural wonders, but they have to be noticed if they are to contribute to our enlightenment. Second, these sites deserve better than to be ground into dust. During its short lifetime Kapoho was such a region; it even played a humble role in one of the great adventures of human history—the lunar landings. I for one wish it could have been saved and watched for a few more years.

William K. Hartmann is senior scientist at the Planetary Science Institute, Tucson, Arizona. This is his third article for Natural History.

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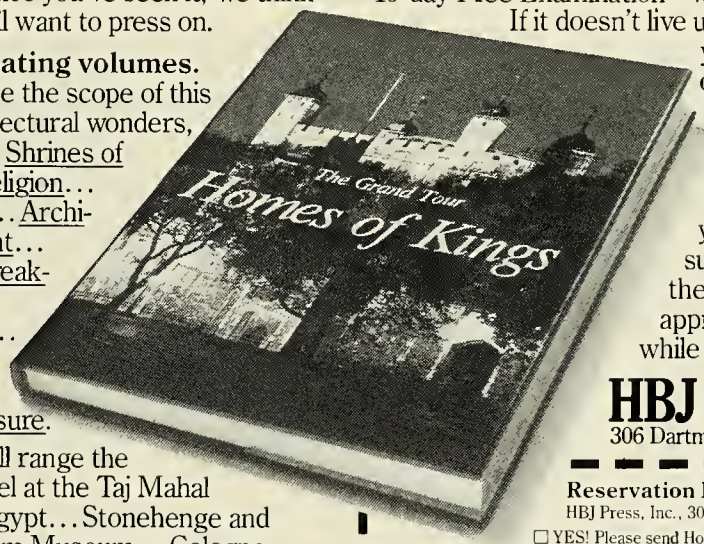


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Drumming Along the Perak

by Edward O. Moll

The riverbank beat of the tuntong has diminished, but this Malaysian terrapin and its prized eggs may be making a comeback—with help from its main predator

By early December the annual monsoon torrents have subsided on the west coast of Malaysia. As the Perak River recedes, its beaches and sand islands, inundated for weeks, begin to reappear, creating the right conditions for the renewal of a centuries-old event—the nest-building and egg-laying activity of the tuntong.

Soundlessly, a female tuntong with a shell length of some twenty inches, her back glistening in the moonlight, emerges from the river. With neck fully extended, she examines the open stretch of sand before her. A few feet away another female comes out of the water, followed by another and another, until thirty or more line the riverbank. Boldness increases with numbers, and the herd begins to lumber hesitantly across the sand. Intermittently, one will stop and press its snout to the sand as if trying to sense the perfect nest site. Some may begin to dig, but more often than not, they move on after throwing sand over their shells several times with their limbs. One site after another is rejected, but finally the search ends and the tuntong begin digging their nests.

The effect of the digging is dazzling. Moonlight reflects off the arched streams of sand being thrown up in all directions, transforming the beach into a silvery fountain. The display continues for some thirty minutes before digging subsides. After a short lull while the eggs are laid, the show resumes with a spectacular auditory sequel to the visual display. Each female now fills the hole and compacts the sand by dropping her 40-pound hulk upon it. The resultant "tun tonk" sound has given rise to this turtle's Malay name, tuntong. As the tuntong drum the sand, the sound drifts along the Perak, announcing as it has for years the annual tuntong nesting ceremony. It is a sound eagerly awaited by Malaysians, who have long cherished tuntong eggs.

The tuntong, or river terrapin (*Batagur baska*), is a member of the Emydidae, a family that includes freshwater turtles and terrapins. *Batagur* inhabits southeastern Asia, along with seventeen other emydid genera and a variety of turtles and tortoises of other families. The coexistence of so many close relatives is possible because of their extensive adaptive radiation into a variety of habitats. Some left the water, the ancestral habitat, to live terrestrially. Others became largely amphibious, dwelling on the forest floor as well as in the small streams, pools, and swamps that abound in rain forests. Still others frequented larger bodies of water—the rivers and few lakes of the region. Finally, a few, such as the tuntong, which is probably descended from a line of exclusively freshwater turtles, encroached upon the sea turtles' domain—the ocean.

For the most part, tuntong inhabit estuaries and the adjacent areas of seacoast, an environment to which they are well adapted. Their slender snouts, powerful hind limbs, and broadly webbed feet bespeak riverine habits. Their serrate jaws tell of a largely herbivorous diet, and their high-domed, seamless, massively buttressed shells presumably discourage predation by carnivores such as the saltwater crocodile.

Throughout most of the year, the tuntong of the Perak live along those parts of its banks and tributaries that are affected by the tides. As the tide rises, the tuntong move upriver, frequently into small, but productive, tributaries. Here they forage until ebb tide when the current carries them downstream. Although the extent of their daily movements is poorly understood, males have home ranges of up to eight river miles and females two miles. Juveniles, being more sedentary, seldom move along more than a quarter-mile stretch of river.

The tuntong usually graze on the stems, leaves, and fruits of riverside plants. On the Perak River, the



In this photograph of a 1903 meeting of rulers of the Malay States and British colonial administrators, Sir Frank Swettenham, second row, center, faces the sultan of Perak, for whom collecting tuntong eggs was an annual event.

fruit of the berembang (*Sonneratia*), a widely distributed mangrove, is a dietary staple. Most feeding occurs at high tide when vegetation is exposed and fruits from low-hanging limbs dangle in the water, but tuntong will eat whenever food is available. I once witnessed a small troop of long-tailed macaques dropping berembang fruit out of a tree into the river. Beneath the tree, several large tuntong had assembled to devour the choice fruit. Mollusks, crustaceans, and fish form a small but frequent dietary supplement.

When and where courtship and mating take place are not known. Males in the Perak River are in breeding coloration by September, and since they do not accompany females on their nesting migration in November, mating presumably occurs sometime in between. Perak River females and juveniles vary from shades of olive gray to green and brown. When the males are not in breeding condition, their coloration resembles that of females but is somewhat darker, particularly on the shell. As the monsoon season approaches, the male's head, neck, and legs turn jet black. In sharp contrast, the iris changes from a yellowish cream color to pure white.

With the subsiding of the monsoons in November, the females, driven by some unknown stimulus, assemble and begin their annual journey upstream to nest. As the river narrows, the bank vegetation —coconut and nipa palms and mangroves—gives way to less salt-tolerant species. Along some stretches, the large, profusely branched, narrow-leaved trees of the gallery forest, or neram, still overhang the river. Where the neram has been cut, feathery clusters of bamboo and lalang grass have replaced the trees. Beyond the river's banks, rubber and oil palm estates have taken the place of the neram.

Sand gradually replaces mud on the bottom of the river, and some fifty miles from the river's mouth, large sand banks and islands, essential for tuntong nesting, emerge from the water. For the next three months, the females lay their eggs here, emerging from the river in staggered waves.

The tuntong's reproductive pattern, similar to that of other large aquatic turtles occupying sizable bodies of water, includes seasonal, communal nesting on ancestral sites, where each female lays several large clutches of small eggs in carefully constructed, covered nests. This survival strategy is extravagant but simple: lay enough eggs enough times and some will survive to carry on the species. The repetition of this pattern, however, is its greatest failing, for predators



The Royal Commonwealth Society

become as attuned to the cycle as the turtles themselves. In this age of television, what armchair naturalist has not accompanied Jacques Cousteau or Marlin Perkins to witness the carnage that takes place on a turtle-nesting beach?

Many turtle species have evolved far less wasteful methods of perpetuating their kind, but being small and unspectacular, they make poor television stars. A host of small, specialized species, including some mud turtles, Malayan box turtles, and spiny hill tortoises, have evolved a reproductive pattern that largely avoids considerable predation. Characteristics of this successful pattern include long, poorly defined nesting seasons and solitary, as opposed to communal, nesting. A female lays only a few eggs, which are so large that they may barely squeeze through her shell opening. Hatchlings from such eggs, being larger, are less subject to predation and a small yolk plug attached to their belly provides sufficient food to carry them through the hazardous early weeks of life.

Why the reproductive patterns of *Batagur* and other large turtles did not evolve along this seemingly more sensible route is difficult to answer. Despite the apparent disadvantages, the tuntong's reproductive pattern has adaptive values best recognized by examining its parts. First, most nestings take place en masse. Prior to World War II, hundreds of tuntongs nested together; now groups of even thirty to fifty are rare. Anyone attempting to locate clutches of eggs can readily understand the advantages of group nesting. Locating a solitary nest would present no problem to an experienced egg collector. The increased traffic on the beach due to group nesting, however, thoroughly obliterates any clues to individual nests.

Nesting behavior, elaborate and surprisingly variable, is another adaptive trait. When tuntongs nest, they excavate both a body pit and an egg cavity. A body pit is simply a large depression, varying from a few inches to more than three feet, which the turtle makes with both its fore and hind limbs. After finishing the pit, the turtle digs a six- to twelve-inch-deep egg cavity within it. Body pits are characteristic of sand-nesting turtles, and at least one function attributed to them is to protect the eggs from extreme surface temperatures. The great variability in pit depths may also benefit the species by increasing a nesting area's capacity. Large numbers of turtles on a small beach frequently destroy each other's nests, but when the nests are at a variety of levels, fewer are ruined.

The number and size of eggs laid are closely linked adaptive features. The body capacity of a female turtle limits the volume of reproductive material at any one time. This creates a dilemma, for while there are advantages to producing both large numbers of progeny and well-developed, large individuals, the two goals conflict. A turtle's clutch size and egg size represent an adaptive compromise evolved over eons of time. In the case of *Batagur*, the average clutch size of twenty-six eggs is somewhat smaller than expected for a large turtle with this type of reproductive pattern. The mean egg size, some one and a half by two and a half inches, is somewhat larger than expected. Larger hatchling size is particularly important to tuntongs because the hatchlings must make the long, hazardous journey back to the river mouth soon after leaving the nest. In this instance, the advantages of large eggs outweigh the advantages of extra numbers.

Tuntongs have developed an elaborate procedure for covering their nests. Whereas digging the pit and laying the eggs require somewhat less than an hour, covering the eggs may exceed two hours. After laying, the turtles scrape sand into their holes and pack them down. They then begin moving toward the river, throwing sand behind them with all four legs. Some six to eight feet away from its nest, each turtle usually digs a false body pit, then continues to move away, always throwing sand backward over its trail. After the false—and occasionally turned-back—trails have been intricately laid out, the turtles enter the water.

At most nesting areas throughout their range, man and tuntong have evolved specific relationships. But nowhere has this association been more colorful than on Malaysia's Perak River, where the collecting of tuntong eggs was long the royal prerogative of the sultan of Perak. Sir Frank Swettenham, an early British official assigned to Perak State, preserved the splendor of this event in a short sketch he wrote at the turn of the century, when tuntong herds numbered in the thousands. Near the end of every year, the sultan's men arrived at the most popular nesting sites, particularly at a large sand island known as Pasir Telor ("egg sand"), to guard against poachers.

The turtles reputedly laid at three intervals. After the first, the guards removed the eggs and delivered them to the sultan. The eggs of the next laying were kept *in situ* for the royal party. The last eggs laid were left in the sand to hatch and maintain the population, a far-sighted conservation measure for the late 1800s.

The riverine dwellers looked forward to the pomp and excitement surrounding the second laying. On the morning following this laying, a messenger traveled to the sultan's palace some fifty miles upriver, while other guards busied themselves locating the nests by probing the sand with long, pointed wood poles. A twig stuck into the sand marked the nest sites. Upon receiving word of the tuntong nesting, the sultan called his family and neighboring chiefs and their families together for the two-day trip. The procession, comprising some fifteen to twenty large houseboats, together with a number of bamboo rafts carrying some 150 egg collectors, must have been imposing. Swettenham described the boats as "graceful and picturesque barges. . . . over the stern half of the boat is built a palm-thatched covering on a slight wooden frame, while cur-

Tuntong hatchlings being reared in a Malaysian hatchery. One-third of all collected eggs goes to the Perak Game Department.



Yong Hoi-sen

A lone female tuntong traverses a well-tracked nesting beach as she returns to the Perak River in early morning.



tains secure privacy." The owner and his family and friends rode within the enclosure on a floor of mats and cushions. The crew occupied the vessel's forward half—with the exception of a steersman who sat high in the stern so that he could see over the cabin.

The boats were draped with colorful flags and many carried gongs and drums. The most gaily decorated boat carried the sultan's principal wife. The covered portion was "decorated with six scarlet-bordered white umbrellas." Two additional umbrellas with black and silver fringes were held by guards who stood throughout the day shading the stateroom entrance. A royal musician seated in the bow played an antique silver trumpet.

The royal ladies of the party dug up the nests. On the morning after their arrival at Pasir Telor, these ladies, dressed in their smartest garments and wearing their costliest jewels, disembarked with a crowd of attendants for the digging ceremony. The beach became a blaze of "brilliant-colored silks, of painted sarongs, cloth-of-gold scarves, and embroidered gauze veils; of bright sunshades, gold bracelets, necklaces, and bangles; of curious jeweled brooches, massive hairpins, and rings flashing the light of diamonds and rubies." Each lady chose a twig-marked nest and with little apparent regard for her costly garments dug through the sand with her hands. Onlookers maintained a friendly rivalry over which lady would find the largest clutch. The competition continued throughout the morning until the heated sand finally forced the parties back to the shelter of the boats. There the celebration continued with swimming and feasting on turtle eggs.

Today, eggs are no longer removed by the sultan's party but rather by collectors who hold licenses for the various nesting areas along the Perak. To obtain a license, each collector must agree to give one-third of his eggs to the sultan and one-third to the Perak Game Department.

Collectors maintain that the koel, a scarlet-eyed, glossy black member of the cuckoo family, leads the tuntong each year up the Perak River to the nesting beaches. Hence the bird's first melodious calls resounding over the Perak in late October or early November signal the licensee to prepare the nesting beaches.

Beliefs about the tuntong tend to be highly localized although similarities to other areas do exist. On northern Malaysia's Kedah River, egg collectors await the arrival of the "raja tuntong," a turtle with a pure white head and a crimson stripe between its eyes, which reputedly leads the tuntong upriver to their nesting areas. This turtle, however, is actually a different species, a painted batagur (*Callagur borneoensis*).

On the Perak River, licensees clean the beaches of lalang grass and sedges to expose the large tracts of open sand necessary to attract tuntong. At one time, large areas of open sand probably occurred naturally on the riverbanks, but silt from years of forest clearing and tin mining has increased the organic matter in the sand to a point where vegetation now flourishes. Ironically, the Perak tuntong have become dependent upon humans for survival, for they could not last long without suitable nesting beaches.

Once they have cleared the beach of vegetation, the men build conical sand hillocks to attract tuntongs to the site. A bamboo post, its upper end split and frayed to hold a cup, is often placed in the center of the mound, making the total height of the structure some five to six feet, about half of which is sand. Various odoriferous substances, such as charcoal or incense, are burned in the cup. Some collectors pour whis-



Edward O. Moll

key over the sand to enhance its drawing power.

Whether the sand mounds actually attract tuntongs to a beach is debatable but not completely dismissible. Tuntongs seem to seek out beaches with high profiles for nesting and certainly the mounds increase the beach's height. During nesting, I have observed that one or more turtles always attempted to lay on or near a mound. Even when only one or two turtles nested, they frequently chose the immediate vicinity of a mound although the entire beach was open. Such behavior, of course, may be the result of the pressure of natural selection to nest near the highest point of a beach, the area usually safest from flooding.

With the beach prepared, the men await the arrival of the turtles; at their appearance, each licensee attempts to lure the herd to his beach. A typical ploy is to anchor bunches of bananas and other fruits in the river near the beach for the turtles to eat. Or at night, the men sit in blinds and pound bricks and rocks on the sand in an attempt to duplicate the sound made by the nesting tuntong. When I studied the turtles, one man went so far as to construct an apparatus consisting of a concrete slab suspended by an inner tube from the roof of a shed. One edge of the slab just touched the ground. By stepping on the slab with the proper rhythm, a man could closely duplicate the drumming of the tuntong. Although no solid evidence exists that this sound attracts the turtles, there is some indication that they can hear it; if one turtle begins drumming, another one usually follows suit.

The egg collectors do not disturb the nesting turtles. At dawn, the collectors probe the sand on the nesting beach with pointed sticks. Despite the female's elaborate cover-up efforts, experienced collectors can usually judge where the buried eggs lie. To ascertain the exact location, they force their poles into the sand to a depth of two

A licensed egg collector excavates a nest on a Perak nesting beach. He may keep one-third of the eggs he finds.



Edward O. Moll

Yong Hoi-sen



A tuntong breaking out of its shell—an event that usually occurs in a deep nest on the sandy beach.

to three feet. If, upon removal, a small ball of sand and yolk clings to the point, then a branch is stuck in the hole to mark the spot. Members of the collector's family follow along to dig up the valuable cache. At times when nesting has been particularly heavy and most clues to individual nest sites are obliterated, collectors resort to hoes and dig up the entire beach in their egg hunt.

Tuntong eggs are a special delicacy in Malaysia and are highly favored over sea turtle or fowl eggs, bringing three to four times the price. No doubt much of their popularity stems from their reputed aphrodisiac properties. Whatever the reason, all collected eggs are quickly sold to the large numbers of villagers who line the beaches hoping to purchase several eggs.

Recent declines in tuntong numbers indicate that the eggs have become too popular and the harvesting too efficient. Before World War II some 450,000 to 650,000 eggs were collected annually; now 20,000 eggs is an exceptionally good harvest. The tuntong's problems, however, are far more widespread than mere overexploitation of their eggs. Their downfall apparently began with World War II. Prior to this time eggs were collected only by the sultan's men, his family, and friends. Female tuntongs were protected, and many eggs were left in the sand to replenish the population. During the Japanese occupation, however, eggs and adults alike were eaten and the tuntong population decreased markedly. It has never recovered, and the odds of it ever doing so become more formidable every year.

Despite protection by law, adults are still regularly killed, many at the hands of Malaysian fishermen. Because hooks can be lost and nets damaged whenever terrapins are unintentionally caught, angered fishermen frequently slit the turtles' throats before throwing them back. Equally destructive are the unlicensed egg collectors who capture females during the nesting season and use various forms of torture to make them lay their eggs. If these measures are unsuccessful they often cut open the turtle and discard all but the eggs. Other turtles are captured and sold for food by poachers. Malays are forbidden by their Islamic religion to eat turtle flesh, but the Chinese, who make up 39 percent of the population of West Malaysia, provide a ready market for the meat.

Perhaps even more destructive to the ultimate survival of the tuntong is the steady deterioration of its habitat. Siltation from mining and industrial pollution, due to insecticides and wastes from the oil palm industry, are steadily reducing the river's carrying capacity. Long stretches of bank have been cleared of vegetation, despite existing laws to the contrary. Many fertile tributary streams have been dammed for roads and irrigation projects.

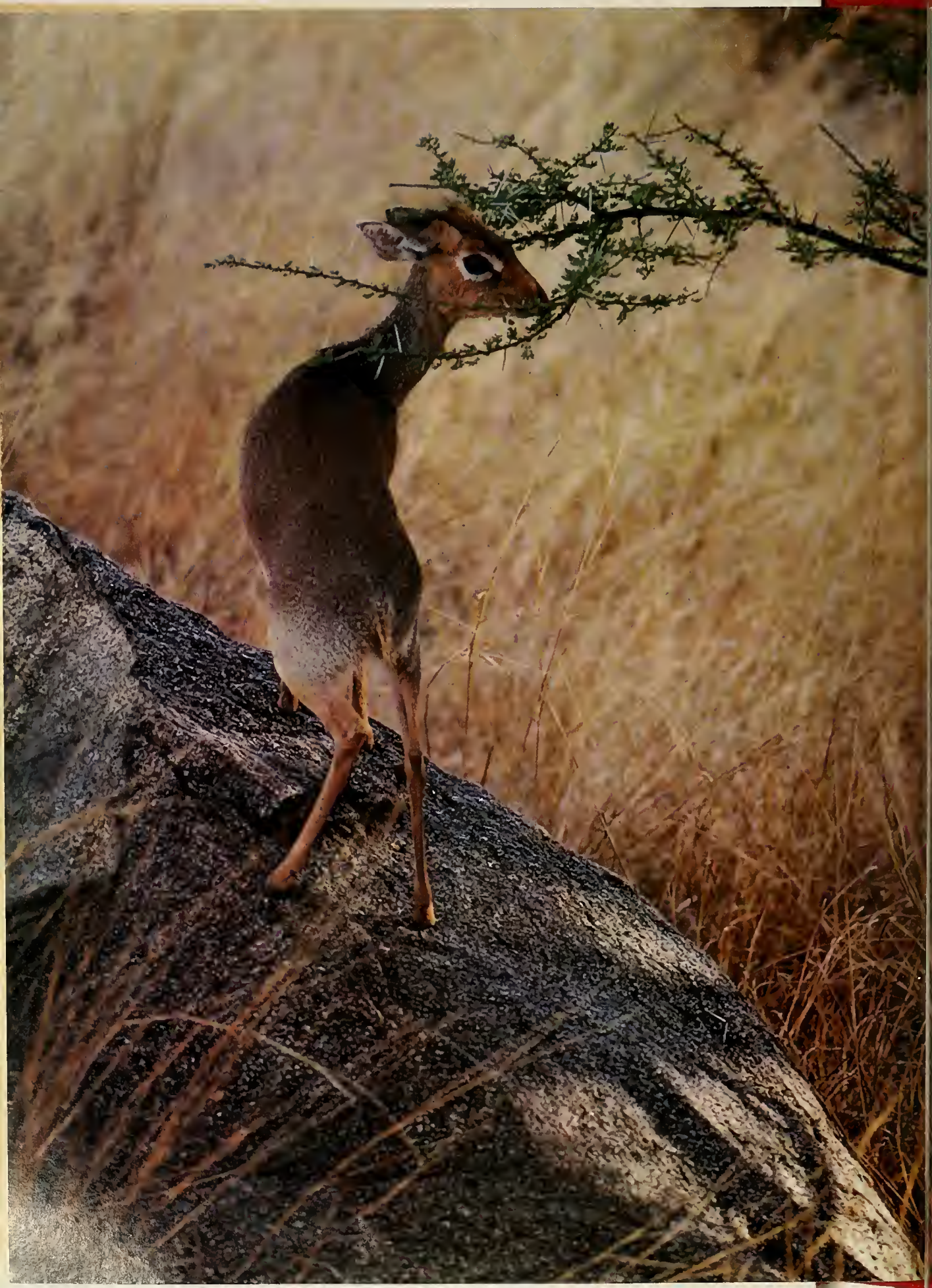
On the positive side, the Malaysian government has always been conservation-minded and is one of the most progressive and enlightened Southeast Asian countries in this regard. In 1967 its game department took over an ineffective hatchery operation begun in the 1950s, and under a new program, some 7,000 yearlings have been released into the Perak River. A recent census shows that the river's tuntong population contains approximately 25 percent juveniles. While small, it is healthy and shows excellent growth potential. The hatchery program seems to be working, but this conclusion cannot be confirmed until many new females begin showing up on the nesting beaches.

With the coming of December, the drumming of the tuntong will again resound along the banks of the Perak. The trumpets, brightly decorated boats, and bejeweled ladies with their fancy silks will be gone. The drumming will be softer now, for the turtles number in the hundreds rather than in the thousands. Still the drumming persists—and with it, the hope that the herds will someday regain their former magnificence so that future generations will have the opportunity to marvel at the tuntong's annual nesting spectacular. □

Another terrapin found in Malaysia, this soft-shelled species (Trionyx cartilagineus) *also lays eggs tasty to humans.*

Jane Burton; Bruce Coleman





Short Ungulates

by G. Causey Whittow

In the rain forest, small deer and antelopes are swift and solitary. On the plains, they dissipate body heat and conserve water with efficiency

Most hoofed animals are large; in fact, some of the largest land animals are ungulates. Giraffes and rhinoceroses are well-known examples of the height and bulk attained by some ungulate species, but there are many others that are conspicuous by any standard of measurement. The larger ungulates are also highly visible because they tend to congregate in herds on open grassland.

At the other end of the size scale is a variety of diminutive, inconspicuous, and little-known species. Many of the smallest ungulates, such as the lesser mouse deer and royal antelope, are wary creatures that live a mainly solitary existence in the forests of tropical Asia and Africa.

All ungulates probably descended from forest mammals similar in many respects to the small antelopes and mouse deer of today. The spread of some of the early forest mammals into grassland would have favored an increase in their body size. Because large animals are endowed with a small surface area in relation to their body mass, in open grassland they would gain relatively less heat from solar radiation. In addition, the body tissues of a big animal can store more metabolic heat. The alternative to storing heat in this way is losing it to the environment.

In a hot climate, significant body heat may be lost only through evaporation of water, either by panting or sweating. Consequently, heat storage saves precious body water, which can be difficult to replace because water sources are often widely separated and periodically scarce on the plains. Heat stored during the day is lost at night, when temperatures are lower, by such nonevaporative means as convection, conduction, and radiation.

The camel is the classic example of an animal that saves water by storing heat during the day and releasing it at night. However, heat storage is widespread in the larger ungulates. Some species, such as Thomson's gazelle, have special vascular arrangements to keep the brain cool, while allowing the temperature of the rest of the body to rise to levels that would damage sensitive brain tissue. In this way, large amounts of heat may be stored, the magnitude of the storage being directly related to the increase in body temperature.

Small mammals are particularly susceptible to dehydration because of their relatively large body surface areas from which water may be lost. Also, their comparatively high metabolic rates increase their oxygen requirements. The relatively greater amount of oxygen is acquired by augmented respiratory activity. An inevitable consequence of increased respiration is a greater rate of evaporation from the respiratory tract and a further loss of body water.

The mouse deer of Southeast Asia, the related water chevrotain of Africa, and the Indian chevrotain are found only in tropical rain forests. These tiny ungulates enjoy one of the most equable climates in the world. Mainly nocturnal, they rarely emerge from the forest cover into open sunlight. On the forest floor, they experience little in the way of daily temperature changes; seasonal changes in such an environment are also minor. A recent experiment conducted in Malaysia revealed that the lesser mouse deer was not particularly well adapted, physiologically, to either heat or cold. The mouse deer has thin, poorly insulated limbs, very little fat, and a sleek coat; it is clearly not designed for cold climates. However, when experimenters exposed the mouse deer to daytime conditions prevailing outside the forest, the animal became distressed. This was probably because mouse deer never encounter the hotter environment outside the forest and have not adapted to such conditions.

Some small antelopes, however, do inhabit extremely dry, semidesert country. Guenther's and Kirk's dikdiks live in this type of environment in East Africa. Both species are so well adapted to arid conditions that they can survive without drinking, deriving their water from the small amount contained in the vegetation they eat and from that produced in the body by metabolism. They are also able to produce very dry feces

Dik-dik Eliot Porter

Peter Johnson



Klipspringers, above, blend easily into their surroundings. Living in rocky terrain, they are as swift and agile as mountain goats. These dwarf antelopes do not drink water regularly. The Malayan mouse deer, right, inhabits lowland forest and is seldom far from water. It traverses tunnellike jungle trails and is solitary most of the year.



Bill Meng. Taken at the Bronx Zoo.



and a highly concentrated urine, resulting in a considerable saving of body water. When dik-diks were deprived of water in an experimental situation and simultaneously exposed to high temperatures, they restricted their panting response so that water loss from the body by way of the respiratory tract was curtailed. Not surprisingly, this resulted in an increase in the animals' body temperature. However, provided that the body temperature does not rise to lethal levels, there is an advantage in a high body temperature during exposure to heat: the temperature difference between the animal and its environment is increased, thereby permitting greater loss of heat from the animal to its surroundings by nonevaporative pathways of heat loss, which do not involve the loss of body water.

In the dik-diks, duikers, and suni of East Africa, and also in the mouse deer of Malaysia, panting rather than sweating is the major avenue of heat loss from the body during heat stress. In contrast, the large ungulates characteristically pant and sweat, but of the two, sweating is the more important means of losing heat. This difference seems to be related to body size. There are limits to the rate at which a large animal can move its relatively heavy chest and respiratory apparatus during panting, and this restricts the amount of heat that



J. K. Grace



Richard Estes

The lone Kirk's dik-dik, above, may be found feeding in proximity to other ungulates, but is generally solitary except during the breeding season. Steinboks, left, can survive for months without any moisture other than that obtained from dew and plant material. These animals are a mated pair.

K. W. Fink, Bruce Coleman



To escape the heat of an African afternoon, an oribi shelters in a stand of tall grasses, above. These small antelopes are active during the morning, evening, and night, when they graze and browse on a variety of grasses and shrubs. The dik-dik, right, is mainly a browser of such shrubs as acacias. When alarmed, it usually dashes off in a series of erratic, zigzag leaps.

may be lost that way. Small animals have fewer such limitations and may attain very high respiratory frequencies during panting, losing commensurately large amounts of heat.

Adaptation to a drier, more open environment is associated with structural as well as physiological changes in small ungulates. The anatomy of their multichambered stomach, for example, seems to reflect both the moisture content of their food and the relative availability of water in the habitat. Mouse deer eat fruits and leaves with a high water content, and water is readily available in the tropical rain forest. One of the stomach chambers, the omasum, is missing in the mouse deer. Believed to play a part in the absorption of water from ingested food, the omasum is, presumably, unnecessary in the mouse deer. The small African oribi, on the other hand, lives in arid country, and its diet has a relatively low water content. The large omasum of the oribi may indicate the importance of absorbing water from food as a conservation measure. This antelope resembles the large ungulates of open grassland, which characteristically have a well-defined omasum.

Dik-diks in the Serengeti give birth to their young twice a year, in June and December. The fawns born in June arrive at the beginning of the long dry season, a testament to the adaptability of these animals to dry conditions. The adaptations of some of the small ungulates to a drier environment were probably a factor in the emergence of the ungulates from the cover of the forest onto the open plains and their subsequent adaptive radiation. Additional information on the thermal biology and water relationships of the small ungulates may provide us with further insights into the evolution of the large ungulates of open grassland.

Meanwhile, the future of small ungulates, while not assured, is brighter than that of many of the large, conspicuous ungulates of open grassland. On the basis of paleontological evidence, small tropical ungulates seem to be relatively generalized in structure. They should therefore be less susceptible to extinction than the larger, more specialized species of the open grassland. Their small size, nocturnal habits, and solitary nature—the reasons for their obscurity today—may be their salvation in the future. □

George Schall




Ben Shahn

Death by Decree

An anthropological approach to capital punishment

by Colin Turnbull

Anthropologists, particularly when in the field, try to be as detached as possible, eschewing value judgments, looking at social institutions in their context. Sometimes I think they become too detached and lose sight of their own social values and responsibilities. Sometimes I think they become detached from humanity itself. Yet anthropology is as much a humanity as a science, if not more so. If we are dealing exclusively with society as a system of interrelated social institutions, then we can achieve a greater legitimate measure of detachment, and indeed we should. But we are also dealing with human beings and with human values, and we have to recognize that human emotions and the need for their expression are powerful forces in shaping the structure of any society. To be truly holistic, which is one of our claims, we must be subjective as well as objective in our quest for truth and meaning. It is not always a comfortable quest, least of all when dealing with an issue such as capital punishment.

In all societies and all legal systems, and certainly in our own, persons are distinguished from things. To persons we attribute inalienable human rights. The institution of slavery was justified, even by Christian moralists, by the simple denial of that basic tenet. We classified one group of persons as things and from that moment on had no moral obligation to them as humans. Joseph Towles, a black American anthropologist, who has some experience of what it is to be treated as a thing, recently pointed out to me the similarity of the process as applied to slaves and as applied to prisoners, particularly those on death row today. He was thinking not only of the deprivation suffered by, and the injury done to, the slaves but also of the deprivation and injury experienced by the masters. (It is now recognized that the institution of slavery eroded the most basic human values throughout the system, brutalizing and dehumanizing both slave and master.) As an anthropologist, he was seeking a structural comparison that would at least explain, although not necessarily justify, the brutalization and dehumanization that take place on death row, recognizing that the tragedy is as great for those in authority as for those subject to it and that, as with slavery, the effects permeate society throughout, threatening our very understanding of the word humanity.

One frequently heard argument is that those on death row are not human. They are often referred to as savages, beasts, subhuman, beyond redemption, animals. The word *animal* is of particular significance to the anthropologist who knows that in many "primitive" societies this is the word used most often to distinguish people from "nonpeople," or "the others." Exactly the same concept of exclusivity underlies racism, religious factionalism, economic warfare, political chauvinism, and other similar characteristics that exist in our modern society, however much we wish it were otherwise.

We cannot avoid recognizing that this concept permeates our society just as strongly as the belief that to classify persons as things is wrong. Why then do we legitimize it in our prison system? Look at the process for a moment if you deny it is so. On entry into prison, a prisoner's name is taken away from him. He is bathed; often his hair is cut. He is disinfected, given a prison uniform, and deprived of contact with the outside world, the world of the living. It is a ritual death of his entire being as a human, comparable in remarkable detail to initiation rituals in which children who are candidates for adulthood are similarly separated from their earlier existence, from family and friends. Their names are taken from them, and they are ritually cleansed and given new uniforms appropriate to their limbo state, until they are ready for induction as the reborn, the final rite being a ritual of rebirth into adulthood. On death row, however, the process is reversed. The candidate enters as a man, is systematically separated from all that manhood is, and placed in limbo until the moment of induction into his new status, death. To the structuralist, the process makes sense. As a humanist, however much I may despise a man who commits murder, I am still

Artwork by Ben Shahn © Kennedy Galleries, Inc., New York

bothered about taking away his humanity. Taking his life is bothersome enough; taking his humanity not only seems logically unjustified (unless we can show that he has *no* human qualities) but far more important, it legalizes the dangerous concept that under certain circumstances—those convenient to society—we may classify certain groups of persons as things and treat them accordingly. Disposable things.

However, let us set about finding the reason for this concept through an examination of the process.

My research has only begun; like all fieldwork it is intensely involving: at times it depresses; at times it inspires. As a humanist I am as much concerned with the families of murder victims, with the lives of the prison officials, with those who pass sentence and those who implement it, as with the lives of the condemned men and women, their families, and the life of society at large. This is not an argument for or against capital punishment. It is an attempt to understand and to provoke the kinds of questions we all ought to be trying to answer. Field research spreads like a weed, and like a weed it occasionally blossoms into flower. Let me give an example so that you can see what I mean.

In the field I enter an African village, and in my notebook I hastily sketch an outline of the village—the disposition of houses and meeting places. Later I supplement these sketches with information about who lives where. I have no idea what the significance will be, I only know that, more likely than not, it will be significant.

So my first visit to death row produced a sketch of a dark, cramped, unventilated basement. There was one corridor, with the ten cells facing each other. Directly behind them was the chamber housing the electric chair. Such light as there was came from an inadequate supply of electricity; ironically, across one end of the corridor ran a huge thick cable carrying an ample supply to the chair.

The next death row I saw was light and airy, up on the second floor. There were some ninety cells (my notes would tell me exactly, but that is close enough for the moment), in two double rows, each back to back, so that each cell looked out only on a heavily barred and empty corridor and through that to the sunny skies of the world beyond. The electric chair was on the ground level, where another, smaller double row of cells, similarly back to back, housed men within one week of execution. At the time, these cells were empty; the second floor was full.

A third was similar in most respects to the second example, except that beyond the empty corridor there were no windows letting in a flood of sunlight; instead yet another heavily barred corridor was patrolled by armed guards, and behind that was a high wall topped by windows that let in some diffused daylight. And there was no large waiting area way down below (this was the top floor), just two tiny cells, barely large enough for a cot, in which the condemned spent their last night prior to taking the short walk to the gas chamber a few feet away. But there was another, more curious difference in the last instance: up on the top floor, each empty corridor was spaced with television sets, one to every three cells, and each cell had a control.

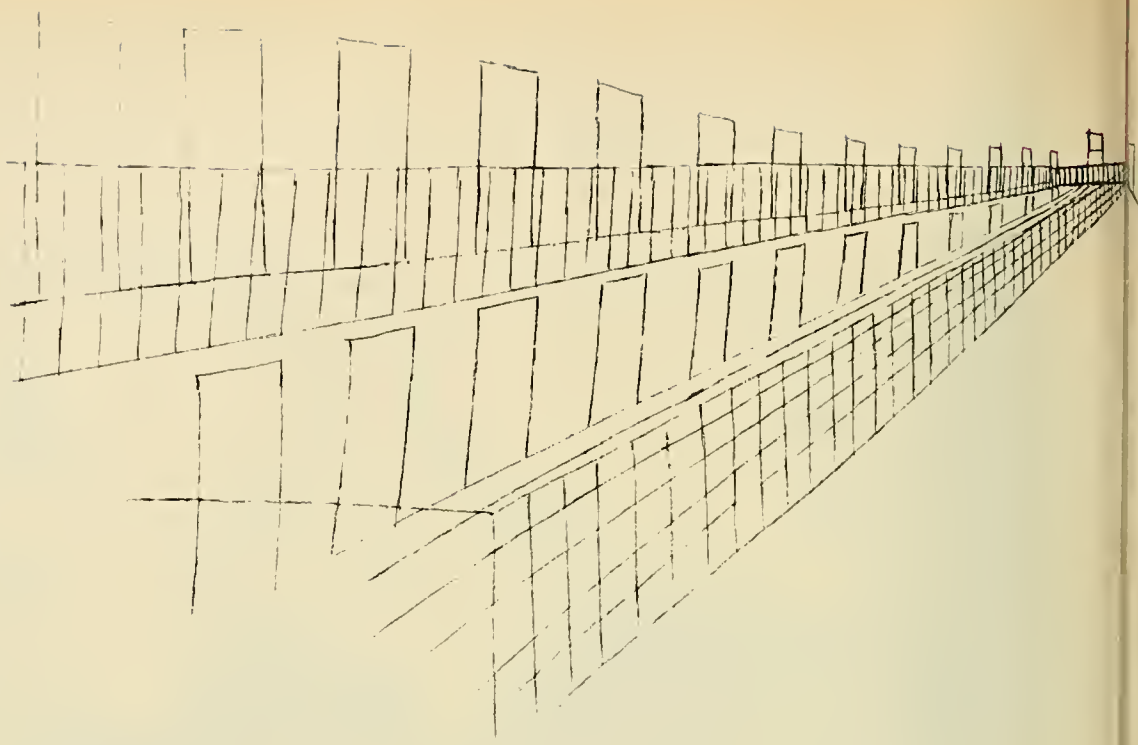
These sketches corresponded to my initial sketches of an African village. I began to look for significance and instantly I was drawn in several different directions, which is why it is impossible to do more than begin to tell the story in such a short account. The significance lay not just with the obvious difference in the quality of living conditions: the amount of fresh air, the adequacy of natural light, the sanitation, and the degree of isolation (the back-to-back cells each had a buttress that projected about three feet beyond the inner cell door, so that from one cell you could not even see the outstretched arm of the person next door). The architecture and furnishings also had to do with security and, in this connection, inmate morale, as well as with the antiquity of the building, which gave little leeway to prison authorities who might have wished for a different design, different living conditions.

A connection was made in my mind between security and morale. I began to look, for instance, at the varied functions of television. For those prisoners who were not semicatatonic, that is, those who were not lying on the cold floor of their cell staring at me with unblinking eyes but not seeing, not moving a muscle as I tried to engage their attention, television provided entertainment and relaxation. But the TV sets also served a much less obvious function; they bound inmates who could not even see each other into social units, within which there was cooperation, caring, and understanding. Each unit came to its own agreement as to which shows to watch and when. These units were rather like sublineages; the lineage as a whole manifests itself during exercise periods when half of one row at a time is taken to the roof for exercise. The television also served to anesthetize, as indeed it does in our living rooms. It drained the energy and sapped the will to think. It thus functioned (which is not to say that it was necessarily installed for this purpose) to take away the will to live. A man about to die surely has something better to do with his time than watch "I Love Lucy." For this very reason, a number of inmates refused television.

The small basement death row, with cells facing each other, with all its disadvantages (it is one of the oldest buildings in the country still in use as a penitentiary) at least afforded the possibility of continual visual communication, but for many years the men were forbidden to talk above a whisper in an attempt to minimize any interaction. It had the disadvantage of being in such proximity to the death chamber that

One frequently heard argument is that those on death row are not human.



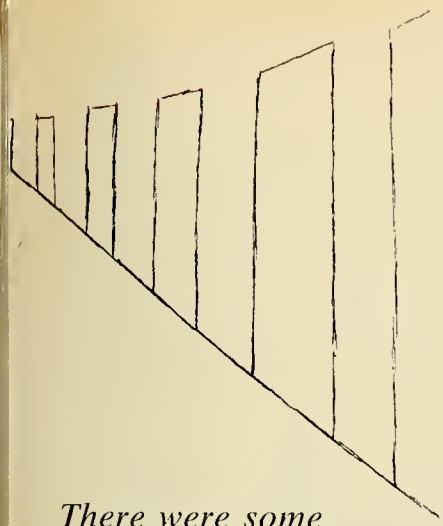


the sound and smell of death was ever present, whereas in other prisons the men were removed from that, at least until the final week or day.

The physical layout also related to the mental condition and attitude of the guards, whose mental health and very lives are endangered by the system. That line of inquiry then sets the anthropologist off on yet another track. In one case the wage level for the guards was at the legal minimum. The job thus attracted those who could not get jobs elsewhere, it was a last resort. Few joined the prison service out of any sense of responsibility, concern, or interest. Consequently, the educational level and morale were low. Induction involved ground rules, learning the physical layout of the prison, and training in combat duty. There was no attempt to help the guard approach the extremely difficult task of maintaining appropriate human relations: keeping the necessary and correct distance, not falling into the trap of being either too friendly or too brutal. Understandably, those who err on the side of compassion (an unpopular term among prison officials) soon collapse under the strain and resign or are hospitalized. Those who survive do so by inuring themselves against the conditions, which leads rapidly to brutalization.

In accepting the assignment to write on capital punishment I immersed myself as much as possible in the reality so studiously avoided by those who support the institution, and about which even those who oppose it often seem so ignorant. I met and talked at length not just with men (and one woman) on death row in four states but also with their guards and with those who would ultimately be involved in their execution: wardens, lawyers, judges, families. The families of victims are harder to reach, but they have been considered just as fully. There is no shortage of testimony to the effect that whereas their initial reaction is to demand vengeance, they ultimately suffer from the knowledge that they are responsible for an ever widening circle of tragedy. Even more depressing than talking with humans waiting to be put to death was talking with that minority of guards who claimed, vigorously, that capital punishment, with all its horror, is both right and good, that the criminals deserve even worse. There were those who said they were eager to volunteer to be present and would enjoy the sight and smell and sound of a murderer being put to death. They were sometimes more graphic than that and took care to communicate their feelings to the condemned. But whereas I might formerly have dismissed them as inhuman savages, I now know too much. I can only wonder that not more are forced, in self-defense, to become brutalized in this way. If I feel any anger and contempt it is not for them, it is for the frightening number of allegedly decent, God-fearing citizens who express similar sentiments from the comfort of their firesides, often refusing adamantly to face the facts.

Tragedy touches all who are affected by the death



There were some ninety cells in two double rows . . . so that each cell looked out only on a heavily barred and empty corridor.

penalty, even the most innocent or those merely fulfilling their duties and trying to uphold law and order. It is measurable in broken families, ill-health, alcoholism, mental breakdown, hospitalization, and for those who survive these ills, in a brutalization born of desperation.

As an anthropologist I cannot avoid remarking on the absence of such a phenomenon in primitive society, where the death penalty is generally not given for offenses against individuals, but only for offenses that threaten the total society. We would call it treason, but in small-scale societies, "blasphemy" would be a better word, referring to any act that could invoke the wrath of the divine against the entire society. Even then, such an act, being more in the nature of a sin than a crime, cannot be corrected by punishment alone. Since the offense was against God, punishment should be left to God; thus we get the invocation of "supernatural sanctions." Atonement is imperative and possible, for the focus is positive, on the good of the total society, rather than negative, on the mere destruction of a single offender; this requires divine intervention rather than punishment. Where it exists in such societies, the death penalty is then a part of the ritual process of appealing to the divine and is totally devoid of the violent demand for retribution found in our society.

This article is written, then, in the hope of creating a wider concern about something that touches us all and involves not only our rights but our most basic human values. It relates to the wider violence that increasingly pervades our lives and against which we are increasingly inured.

The first step in classical anthropological observation and analysis is descriptive ethnography—to observe and describe without academic or personal prejudice. This is where anthropologists demand of themselves an objectivity that is as complete and free of value judgments as possible. This is also where our holistic concept is important, for since we are unencumbered by theoretical considerations at this stage, we have no preconceptions as to what might be significant or insignificant—we observe and note everything around us, however trivial it might seem at the time, for we are interested in the total social system, not just one part of it.

In this case, although I am concerned with capital punishment as an institution and its interrelationships with other institutions, I am also concerned with the value system within which it operates and therefore interested in opinions, which are value statements, regarding it. As an observer then, without initial judgment concerning capital punishment itself, I look at: (1) the common arguments *for* capital punishment; (2) the common arguments *against* capital punishment; (3) the nature of capital punishment.

Only then am I in a position to assess and interpret the role of the institution in our society and determine just how far it affects the lives of every one of us in that society.

The arguments for capital punishment:

1. It is a deterrent
2. It prevents recurrence
3. It is a moral duty
4. It is more economical than life imprisonment
5. It is kinder than life imprisonment
6. Those sentenced to death are only the worst offenders and are beyond rehabilitation
7. Those sentenced to death are beyond humanity and therefore deserve no consideration as such (a counterargument to "cruel and unusual punishment")
8. "We don't know what else to do, and we have to do something," an argument first stated to me by a prominent judge who, as a lawyer, had successfully won the restoration of the death penalty in one state, yet was willing to concede all arguments except this one.

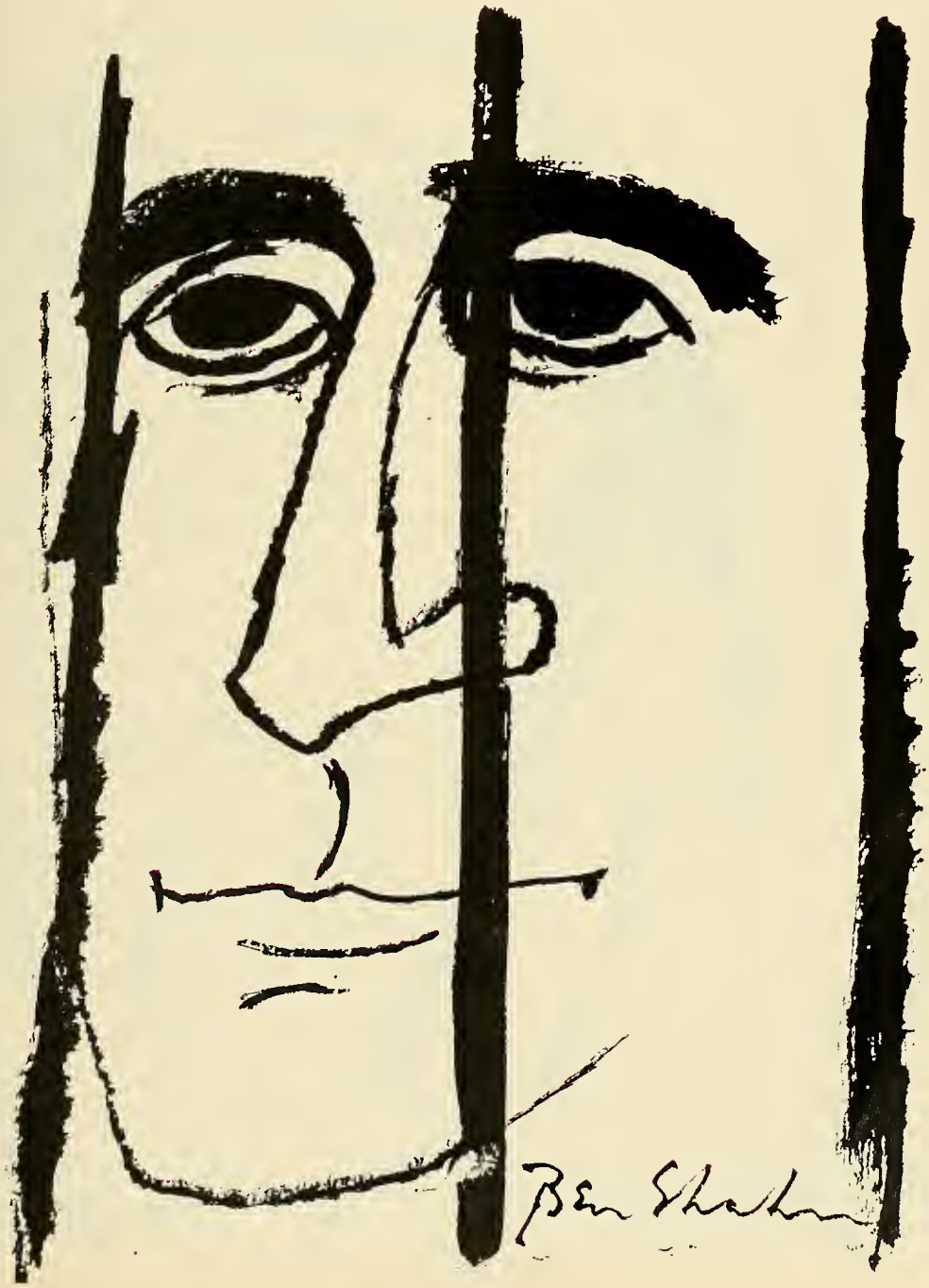
The arguments against capital punishment:

1. It is not a deterrent. Here again it is necessary to stress that the best-informed opinion within the legal system is, at best, divided, since the argument is as impossible of proof as it is of disproof. Every murder committed where subject to the death

penalty is positive proof that in that case the penalty was *not* a deterrent. Clinton Duffy, who as warden of San Quentin witnessed ninety executions and dealt with many of the most hardened criminals in the country, said of the death penalty, "It is not a deterrent to crime . . . . I have yet to meet the man who let the thought of the gas chamber stop him from committing murder." Hard data support this view. There has been a slightly higher murder rate in some states having a death penalty. The abolition or introduction of the penalty does not make *any* significant difference in the rate of commission of capital crimes; in any case, such fluctuation can only be assessed in relationship to other considerations as well, such as a changing social context. The only valid rational verdict on deterrence, then, is "not proved."

2. It does not necessarily prevent recurrence. The only validity of the "prevention" argument for the death penalty is that in killing a murderer we prevent the possibility of that one man murdering again. Of the more than four hundred men and women on death row at this moment or of the thousands executed in this country recently (about four thousand in the last forty years) few had committed more than one murder or showed evidence they were likely to do so. The great majority were crimes of the passion of a single moment, and although such people need to be restrained, confinement would do that as well as execution and would seem more appropriate.
3. It is not a moral duty. Those who try to justify capital punishment on moral grounds can only cite ancient Hebraic law ("Eye for eye. . . .") which, in itself, is susceptible to different interpretations and was in any case applicable in a totally different context some two thousand years ago. Further, the major churches have argued strongly *against* capital punishment. The significant discrepancy between church leadership and the extent to which it is followed by nominal adherents has to be explained, and the explanation is probably that the churches, no more than other anti-capital punishment bodies, have failed to come up with an effective alternative or even with effective arguments other than a direct moral commitment.
4. It is not more economical, necessarily, to execute a criminal than to keep him in confinement for life. The cost to the state of a capital offense trial and of all the subsequent appeals is exorbitant, as is the added cost of maintaining a prisoner on death row for what might be many years of appeal. Summary execution would of course reduce that cost and would add something to the possibility of the penalty acting as a deterrent, but is unacceptable under our present concept of justice and due process. For those unwilling to accept that anyone in authority would consider mere economics in an issue of such gravity, I cite the recent case where the warden of a state penitentiary asked for legalization of lethal injection as a means of execution because it would cost only one dollar per head! Against that kind of thinking there is no refutation.
5. It is not "kinder" than keeping a man in prison for life unless prison conditions are admittedly inhumane. In any case, it is inconsistent to invoke "kindness" in this one respect, yet ignore it when it comes to consideration of the extreme deprivation, physical and psychological, under which prisoners live on death row. There might be an argument for giving a choice, but that would be legalizing suicide in the same sense that execution legalizes murder.
6. It has been clearly demonstrated and confirmed by prison officials that those sentenced to die are not beyond rehabilitation. Faced with this extreme crisis, many prisoners often reflect on life and sociality in a way they might never have done otherwise. In cases where such men have had their sentence commuted they sometimes become model prisoners and form a constructive and stable element of the general prison population. It is almost as though, by accident, we have discovered the secret of rehabilitation, in rather a drastic way. Such data might be of the greatest significance in the wider area of prison reform and rehabilitation. Murderers and other prisoners I have talked with frequently express a deep frustration at being denied the possibility of making effective atonement. Punishment alone is not atonement.
7. The experience of prison wardens alone demonstrates that convicted murderers may, at least, have human potential. That is a negative way of stating the issue, which is of much greater significance. I refer to the concept of justice found in most primitive societies, where an offender is judged not only for that offense but also for his positive attributes. Even a murderer, after all, might be a good father, an admirable husband, a cooperative and productive craftsman, and a devoutly religious person. In executing that part of him that is "bad" we also execute the good. Even if that had to be so, then should we not continue to grant the condemned person the right to be treated as a human being until the moment of his death, and give him the opportunity to prepare for and meet his death with the decency and dignity our law demands for all human beings?
8. We may not know what else to do, but there is no way that we can demonstrate that nothing else *can* be done. We have examples of alternatives even within our own country, let alone in foreign countries that have completely abandoned the death

For if we expect them ever to be fit to return to society, their conditions of confinement must be consistent with our concept of humanity.



penalty. We cannot declare that an equally effective solution to murder is impossible, since one cannot logically deny the existence of that which is not known. If successful alternatives have been found in other societies and if we value the sanctity of all human life, even that of humans who have committed crimes, then we are logically bound to search for such alternatives. Regrettably, it is both easier and cheaper not to do so, and this places in question whether our stated human values are any longer valid. Such a quest for an alternative is within our intellectual ability and our financial capability; it is merely a matter of choice and will.

While the above constitute refutations of arguments in support of capital punishment, opponents of capital punishment have two irrefutable arguments. The first



Prospective candidates for electrocution can see the chair during their incarceration.

is the possibility of mistake. We know that innocent victims have been executed; fortunately, others condemned to death have been found innocent prior to execution. And we have to face the very real possibility that other mistakes have never been discovered because following execution, the incentive for costly investigation to prove innocence is largely gone; in nearly all instances the cases of those who maintained their innocence until the moment of death are dropped at that time.

The other irrefutable argument against capital punishment is the existence of two prime factors—caprice and selectivity—that effectively determine who shall die and who shall not. Let me cite three of the most obvious demonstrations of this process at work. The proportion of black Americans on death row is totally



inconsistent not only with their numbers in relation to the total population but with the numbers of all convicted murderers, black or white. Furthermore, although more than half the murder victims in the United States are black, Dr. Riedel, of the University of Pennsylvania, has shown that in 87 percent of the cases where the death penalty was given, the victim was white. And there is virtually a total absence of persons of any wealth, even moderate, on death row. The penalty clearly selects poor and black, those least able to afford the expert defense such a charge necessitates and whose guilt is most likely to be accepted without protest by the general public. Finally the death penalty discriminates heavily against males. Few women have faced a capital charge, and fewer still have been executed.

The nature of capital punishment

Even in description the approach of anthropology is dual—or should be. As a science it looks for organization, structure, consistency; it is involved with the total dynamics. As a humanity it is concerned with values and with people. In this latter respect we have to deal with whether capital punishment is cruel and unusual. One might think that this issue is the province of lawyers, and to some extent it is, but their proper concern is legality rather than humanity. And their discussion as to whether the nature of capital punishment is cruel and unusual invariably ends in a split vote. Note that a majority of one is all that is required for a decision, and it is on such an evenly divided opinion that the lives of people now awaiting execution depend. What firm of engineers would accept such a close margin of opinion on the stress factor in their construction of a bridge or building? What firm of stockbrokers would accept such a basis for undertaking a major financial enterprise? It is not the lawyers who are to blame, still less the prison officials who have to implement the law. It is those who make the law, and in a democracy that means the general public. One might hope that religious leaders, if they felt deeply enough that this was an issue of moral significance, would be more active in offering guidance to the public. But the responsibility still lies with the people, and either the people are apathetic or else they often act blindly out of an ignorance of the facts, which are difficult to reach. When we consider the issue of humanity then, let us be clear that we do so not out of misguided sympathy for the criminal alone but out of concern for all those touched by the crime—which means all of us.

But one last caution before I describe death row, before we look at the actual process. The word *cruel*, as in cruel and unusual punishment, is a dangerous red herring, for it implies motivation, intent. We are safer to focus on *humanity* and *inhumanity*, each of us defining these words in light of our own beliefs, but also in light of the ideals of civilization. For instance, one would think it undeniably cruel to execute a man following one or more previous attempts that had been thwarted by failure of the equipment. There is a common belief that in such an event the condemned person's life is spared. Not at all. Here again, caprice, the caprice of commutation, comes in, and no rules have been established to guide such a decision, which then rests on whim. Willie Francis did not die at his first scheduled execution because the electric chair failed. There was an outcry against a second attempt. Learned arguments showed that no cruelty was involved since there was no intent nor, presumably, was it unusual since it is the inherent nature of mechanical equipment to fail. The next time the mechanical equipment did not fail. One of the first men to be electrocuted in New York State (the first state to use electricity) was being buried when he returned to life. He was brought back and electrocuted more successfully. The very first man executed in the new chair at Auburn, New York, was pronounced dead after seventeen seconds, but he then showed signs of life and more current was applied. This was regrettable because the prolonged charge caused the flesh to burn and one argument for the new device had been that it was so quick it would not mar the body. It still burns the flesh and several charges are still necessary before death occurs.

The technology

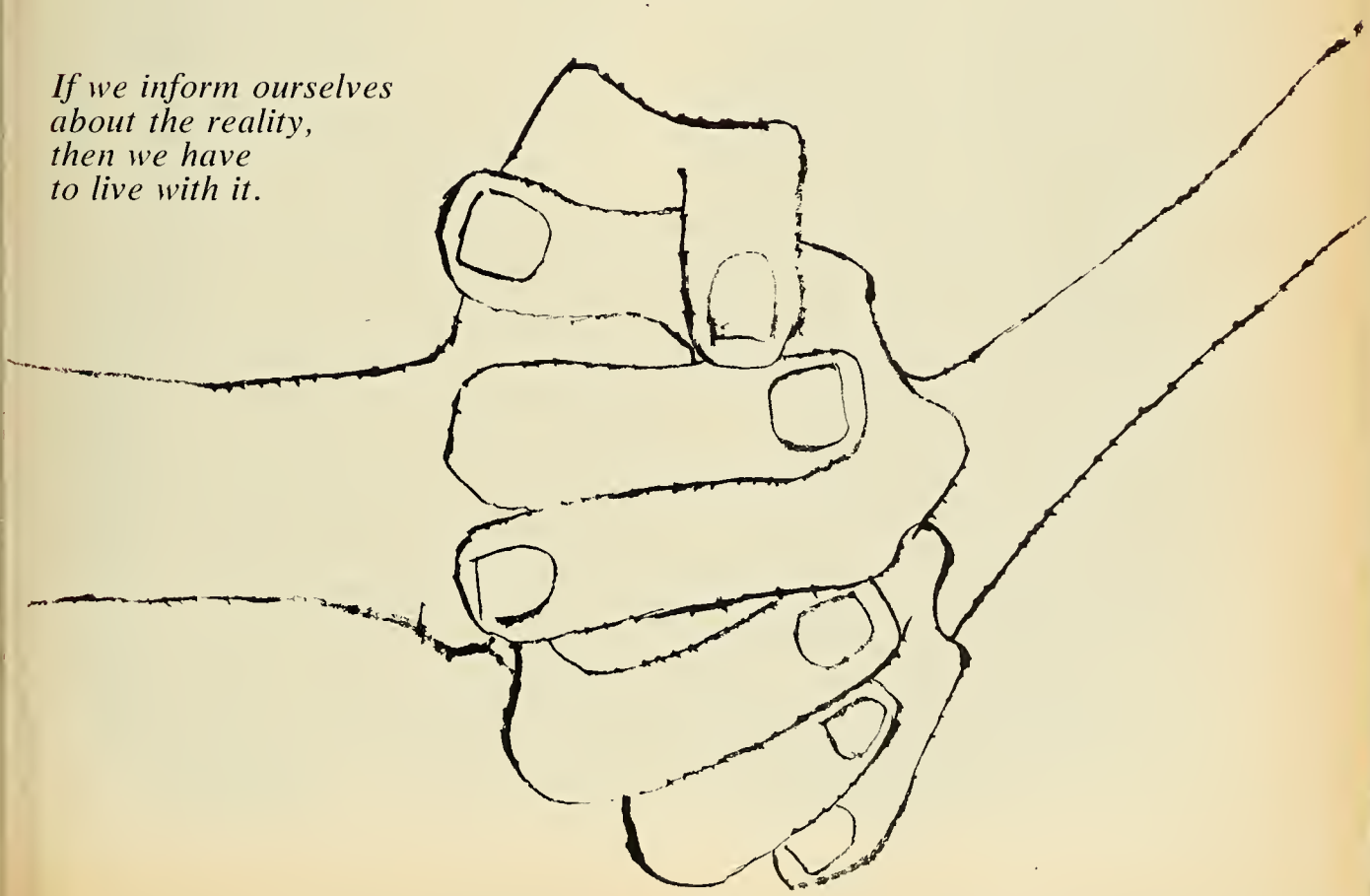
The technology used for execution today is, to say the least, far below our technological capability. This is not a gratuitous swipe at technology or at the system. It is an observation of fact. In none of the four lawful modes of execution, not counting the yet unused drug now being legalized in a few states, is death instantaneous. In all, the body is mutilated, least so in the gas chamber, where about seven minutes elapse before the outside stethoscope registers cessation of heartbeat. We are not sure at just what point consciousness is lost, just when the incredible pain ceases. We have nearly all suffered from minor electrical shock, a mere 110 volts as against 2,300; or from smoke inhalation if only from an unwilling log fire; or from mild asphyxiation when momentarily we choke on some morsel of food. None of those sensations is pleasant. When a man or woman is hanged, death occurs after eight to ten minutes. In hanging, death is rarely caused by the breaking of the neck; medical evidence indicates quite the contrary, strangulation causes death. Warden Clinton Duffy reveals that when a body is cut down and the mask is removed, "the side of the face has been torn open in more cases than not." He also reports that even after the doctor has certified death, the body is left hanging for another ten or fifteen minutes, just in case. The same method was used in England,

where the most careful studies had been made on how best to achieve death through hanging. Before the importance of the distance through which weight falls was recognized, a drop of six to eight inches was considered adequate. Prior to that there had been discussion as to where the knot of the noose should be placed, and whether it should be drawn tightly (a knot pulled fairly tightly beneath the ear was thought to lessen the length and pain of strangulation). But then it was recognized that the longer drop was more effective, and sometimes as much as eighteen inches was used. The problem that worried authorities then was that the head was often torn off, depending on the weight of the body. Eventually, just before the turn of the century, the Home Office set down a regular scale of drops calculated according to the weight of the victim and allowing some latitude to the executioner; this was meant to insure that death was as rapid as possible *without* tearing the head off, plainly a gruesome sight for witnesses. So the victim strangled to death, but his head remained on his body.

Shooting is probably quick enough, but it does disfigure and death is not necessarily instantaneous. The gas chamber is usually the least disfiguring, if the slowest; it effectively causes death by asphyxiation and there is no record that it ever failed. There is, however, a relatively long waiting period after the victim has been strapped into the chair. During this time he or she can hear the machinery being set in motion, the suction valves and vents at work, the introduction of acid gurgling up into the basin beneath the chair, the movement of the levers that release the cyanide pellets, the drop of the pellet into the acid, and the subsequent hiss as the pellet dissolves and the gas is released. Only at the point that the gas reaches the lungs (and this depends on how long the victim holds his breath) does consciousness begin to fade. The only disfiguration is some discoloration of the face and marks made by the restraining straps if the victim struggles. I do not know if earplugs are allowed to reduce the unpleasant sound effects; a blindfold or face covering *is* allowed, but elsewhere I have been told (in a prison that executes by electrocution) that no sedatives are allowed "because the criminal has to be fully aware of what is happening to him."

Then why cover the face? Clinton Duffy suggests an answer. In many cases, the witnesses who by law must be present, as well as the officials (perhaps as many as thirteen or fourteen), become sick: some vomit, some pass out, and the sight of what happens to the face

If we inform ourselves about the reality, then we have to live with it.



would be too much to bear. He explains that witnesses to a hanging are dismissed after the drop, before the victim is cut down and the hood removed, revealing the torn face. (Some medical authorities say that such tearing should not take place, but that following death by strangulation there is considerable concentration of blood at the surface, and given the angle of the head with the noose clinched up behind the left ear, this gross discoloration will appear on one side of the face.)

However, the worst results obtain with electrocution. Originally a verb was coined and it was said that a criminal was "Westinghoused," since it was Westinghouse equipment that won the battle of Auburn (a battle between rival commercial interests) and was first used there, on August 6, 1890. The first equipment I saw had the uncomfortably familiar name General Electric inscribed attractively across the case. I have not felt the same about any electrical equipment since, but someone has to build the machinery, and it is built to the very best specifications. Twenty-three hundred volts, or thereabouts, is generally prescribed, administered in alternation with charges of up to 1,000 volts in some cases. After eight cycles of 2,250 volts followed by 1,000 volts, a total of two minutes electrocution, the heart may not have stopped, and further cycles may have to be administered. Even if one two-minute cycle proves adequate, there may be considerable burning, causing both smoke and the smell of burning flesh. For this reason, the death rooms I have seen have the witness boxes glassed in so that at least the smell does not penetrate. However, sound may be piped in, so that the witnesses hear all that is going on, and not all victims go to their death quickly and without protest, for this incredibly inefficient technology demands protracted preparation of the victim, even in the chair. Prior to that the head is shaved to insure good contact, so are other parts of the body to which contacts have to be applied, most often one leg (contacts on both legs can short across, causing even more burning). Then the victim is strapped tightly into the chair: legs, arms, chest, and head. A brine solution must be applied, although there is some disagreement about this—it reduces burning but some say that it also reduces the efficiency that would be achieved by direct metal to skin contact. Next, the execution order is read, last words solicited, and with everything ready, the equipment is tested, which involves the victim hearing the opening and closing of the electrical contacts and switches and the hum of the generator. Only then is the current transferred from the test circuit to the chair, and the two-minute death dance begins. The head is held rigidly by a leather cap and chin strap; the eyes, which may come out of their sockets, are masked. Urine, inevitably, is released. One chair, in a prison I visited, has a cunningly devised hinged back, with a wedge placed at the opening at the top, so that as the victim's body strains at the straps, the wedge slips down keeping them tight throughout.

When the body is removed it is frozen in a grotesque position and is taken to what is known in one prison as "the sandbag room," where it is straightened so that it can be fitted into a coffin. The more progressive prisons—or those that can afford the improvement—have an exhaust vent above the chair to remove as much of the smell as possible. In the case of multiple executions, this is of little comfort to the next in line since the smell of burning flesh is singularly pervasive. Nor of course is it of much comfort to prison officials who have to be around the chair or to witnesses where there is no odor-proof witness room. The sight and sound alone are enough to threaten one's sanity.

Let me say here that I have not witnessed an electrocution. But I have spoken at length with those who have and with those who are waiting to die and who know every detail I have described and more. I have seen two men hanged. And I have been on a dank basement death row where the cells in which condemned men wait to be put to death back directly onto the death chamber, separated by one thin wall. There are two corridors, one at each end of that death row, and both connect with the death chamber. There is no ventilation. Prospective candidates for electrocution can see the chair during their incarceration; in fact, such an opportunity is sometimes offered by kindly authorities. There is no way that the smell and sound cannot permeate that death row, and on a damp day the smell is rank, even if there has not been an execution for months—some say years. When I was last there, it had all been freshly painted in readiness for the next execution, so all one could smell was paint, and hopelessness.

Once every two weeks, into that basement, came the executioner (usually the captain of the guard, but in some states, an unknown, hooded outside volunteer). As described by every inmate I interviewed, the procedure was for the executioner to first walk through death row itself, which was not at all necessary for he could have passed directly into the death chamber. But he wanted to be seen. He would talk to a prisoner but never look him in the eyes. Then he went about his task, testing the equipment. One inmate lived fourteen years, another ten years, others for seven and eight years knowing what was waiting for them. Every two weeks they heard the throwing of switches, the whine of the generator, fluctuating from a dull, low hum to a high-pitched squeal. (One of these men I know had three times been served his ritual "last supper," had had his head shaved three times. Now, with his sentence commuted owing to one of the many technical fluctuations in the on/off game, he keeps his head shaved at all times.) The inmates could hear "Mad Jack," as they called the executioner, clump out of the chamber, into the dark alleyway and

All this horror . . . is surely one of the most telling arguments against capital punishment.



Tragedy touches all who are affected by the death penalty, even the most innocent.



up the steps that led into the sunlight of the main yard, with its green lawns and flowerbeds. Mad Jack was eventually hospitalized and forced into early retirement. Guards, who merely have to sit at one end of death row and, with the prisoners, wait, become alcoholics. Divorce is common among guards. Like the inmates, they see individuals led out one morning, sometimes from pools of vomit, urine, and feces, control over which has been lost through fear. At such times, some guards exhort the condemned to "take his medicine like a man," although until then they referred to him only as an animal. They hear the screams of protest (or the whines of sobbing or the silence), hear the generators start their song, and then smell that smell. (Incidentally, lights do not dim all over the prison these days, in most cases the electric chair is on a separate circuit.)

All this horror, a result of the technology, is surely one of the most telling arguments against capital punishment, for the strain and stress, the alcoholism, broken families, and mental breakdown reach out beyond the confines of the prison. So does the brutalization that mars the lives not only of inmates but of all those touched by the death penalty, the same brutalization that enables me to write this account in the comfort of my home, while good and kindly friends, whom I have come to know and respect, wait to sit in that chair. If we inform ourselves about the reality, then we have to live with it, and the only way to do that is either to suffer or to steel ourselves against it, a hardening process that makes us that much less human. I have met judges and wardens and lawyers who have not been able to sleep, even though they claim to believe in the death penalty. And I have lunched with guards almost above the death chamber and heard them say how they look forward to the next execution, how they will enjoy the smell of burning flesh. If this is not inhumanity, I do not know what is. So much for our value of "compassion."

There is more—so much more—but this has to be enough. What sense does capital punishment make? It exists in this particular form and therefore, the anthropologist says it is likely to have reason, to make sense, somehow to be necessary for the survival of our society. Perhaps so, but I refuse to admit there is no alternative, for that would be to admit there is an end to humanity. I think back to the final reasoning of the judge who successfully fought to have the death penalty reinstated: What else can we do?

There *is* a desperate situation. Murder seems to have almost become a pastime. We all want to feel safe on the streets, safe in our homes. We are not in authority, so we have the right to demand of those who are that "something be done." I have just described what they do. The deliberate taking of human life is sensational, perhaps the most dramatic act that can be performed, total and irrevocable. It is permeated with religious and ritual elements: the last supper, the gowned and hooded executioner in one state; in another, the compulsory walk down "the last mile" (in this case, an outside corridor, actually only a few yards long, during which the condemned person is commanded to look upward and see the sky above for the last time); the formal reading of the death warrant; the presence of a congregation of witnesses. An anthropological study could be done of the ritual elements alone.

We need to break many more barriers, to get much more information through free and frank interviews with all concerned before we can attempt any significant analysis. That I, an academic, was given such free access to prisons in the states of Virginia, Georgia, Florida, and California is evidence of concern on the part of correctional authorities. But one clue, for me, lies in this ritual element, which is the only way that all the horror, an essential part of the institution, makes sense. It then appears in the nature of a sacrifice, but one that is not truly public. This dramatic, awesome ritual offering, is made precisely at a time when we have no other recourse, when we do not know what else to do. At such a time, in primitive society, the gods are invoked. When man recognizes his impotence, he falls back on the unknown. Then even caprice makes sense, and the execution of innocent people becomes immaterial from a functionalist point of view (although never, I hope, from a human, moral point of view). For all that is demanded is a token, a ritual sacrifice.

All other considerations aside, our system is supremely inefficient. We are only accomplishing the disposal of a number of human beings, many of whom are perfectly good people who may have, in a moment of passion, committed a single crime; some may even be totally innocent. We do this in a way that is singularly barbaric, enormously expensive to the public at large, and more particularly, detrimental to the mental and physical health of all those involved. And while we do all this in the name of society at large, the focus is kept firmly on the individual crime and the individual criminal, who is disposed of without any opportunity for atonement. If the entire process were more public; indeed if judge and jurors were compelled to participate in the execution, and if their attention as well as the attention and concern of the rest of society were focused on the need for goodness in society instead of the mere sordid destruction of one individual, then perhaps something might be accomplished by capital punishment.

But if we were that concerned with the well-being of society, there would be little or no need for capital punishment in the first place. Meanwhile it persists merely to provide the public with the illusion that something is being done.

The alternatives

One of our often stated values is progress, and in both the prevention of crime and our manner of dealing with criminals, it is difficult to find much evidence of progress. Each step we take seems to be countered by a step on the other side.

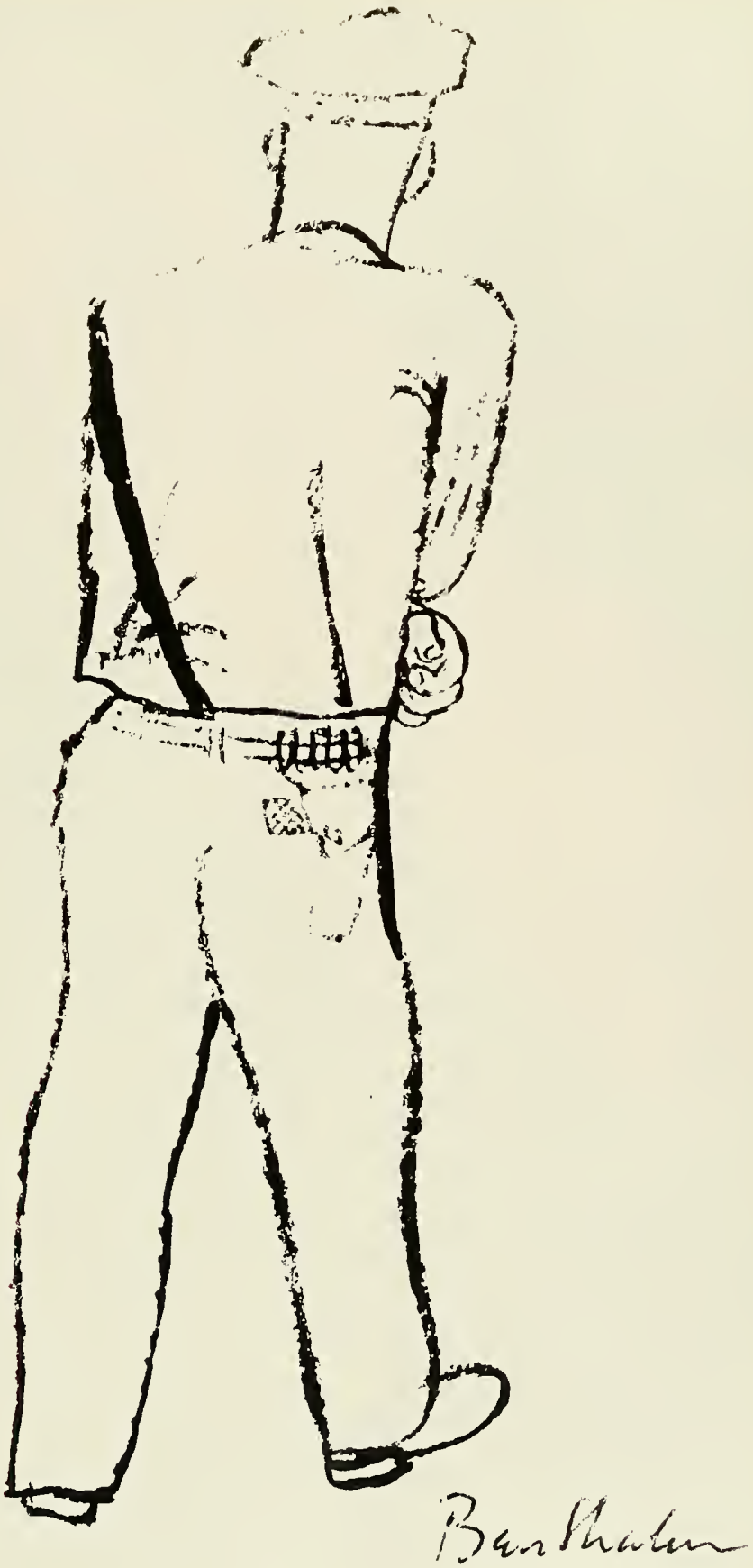
A cross-cultural perspective points up possibilities, some of which are being incorporated into the more advanced thinking within our jural and penal systems. Most such studies, however, deal with small-scale societies, and the transfer of concepts from one context to the other is not easy; they serve better as indicators, prompting us to ask the right questions about our own system. For instance, in most such societies there is the total absence of anything corresponding to our police force and little that corresponds to our legal system. Yet there is order and justice in measure that we could envy. Two important differences should be noted. The first is that the focus is not on the nature of the act, be it murder, theft, adultery, or whatever, so much as on the social implications of the act. Hearings (rather than "trials") involve consideration of motivation and social result; the welfare of the society at large, rather than that of the individual, is being considered. Thus while any of those acts is normally "wrong," there is always the question of degree. With us, extenuating circumstances are secondary; elsewhere they are primary and "sentencing" is correspondingly focused on the welfare of society. Under our legal system it is focused more on the crime itself and on an appropriate penalty. Although we give the name Department of Corrections or Department of Rehabilitation to constituted bodies, they serve rather to punish. Elsewhere judgment serves society by emphasizing restitution rather than retribution. A thief is made to work until he has restored the value of what he has stolen or destroyed. A murderer cannot restore the life of the individual, but with the focus on social implication, that is not primary; what *is* primary and possible is that he fulfill the social obligations of the person he has killed. If he has killed a married man with a family, he must in some way care for the wife and the children, and this may even go as far as his being adopted into that family as a server—an institution sometimes mistaken for slavery. At the same time the public is made aware of the individual's potential for murder, so that appropriate caution may be exercised or restraints imposed. Sometimes a second offense *is* met by the death penalty.

In the United States a few states have actually implemented comparable programs with restitution as the goal. In Minnesota such a program was shown to produce, among other benefits, a lower rate of recidivism, according to a study made by the National Council on Crime and Delinquency. The same source cites another program in California where offenders are required to work for their victims (or for the community) in lieu of a jail sentence, thus not only vastly reducing the cost to the state but also providing material assistance where needed. And in a similar program in Michigan involving less than a hundred offenders, the state saved some $400,000. The rate of recidivism is always lower, a much more significant benefit in the long run. So far, these and the more common work-release programs found elsewhere are for lesser felonies, but they all suggest a major area of exploration in our search for alternatives to the death penalty. For some time, life imprisonment has been an accepted alternative. The common objections were that it cost too much and was not a severe enough punishment.

Among those in authority there is a widespread desire to improve conditions, to implement well-tested programs such as those outlined above and, for criminals who cannot be safely returned to the outside world, to provide opportunities within prisons for gainful employment at union wages. From those wages, however, deductions would be made for board and lodging, for restitution to victims and/or their families, and for maintenance of the offender's family, removing them from welfare. This would not only save enormous sums of money, but would also provide those conditions that would make for more effective rehabilitation. There is no question of making such prisons into hotels. Those who voice this complaint know little or nothing about life in confinement and little or nothing about criminals. For if we expect them ever to be fit to return to society, their conditions of confinement must be consistent with our concept of humanity. This means, at the very least, allowing the prisoner the respect and dignity due all human beings.

Ultimately, we are forced to face that gut-level question that contributes to the highly emotional nature of most discussions of capital punishment. Is the murderer human or has he in a sense resigned from the human race and thus deserving of no human consideration? To answer this question, we have to face, without flinching, the grim realities of all that is involved in the death penalty; to recognize that it is not merely the criminal we are considering, it is all those others, and finally, ourselves. And until we face the harsh facts of what happens on death row and in the execution room, in the witness room and in the offices and homes of prison officials, lawyers, and judges, we are not entitled to have an opinion and call it reasonable or just.

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Ben Shahn



The Fierce and Fatherly Siamese Fighting Fish

Ounce for ounce, a male Siamese fighting fish has to be one of the most pugnacious coldblooded vertebrates known. Strongly territorial, he will attack an intruding male, a female in his vicinity under the wrong circumstances, and his own reflection. With fins outspread, body taut, and gill membranes expanded like the hackles of an enraged rooster, this roughly 1¾-inch-long carnivore will nip and bite until his adversary beats a retreat or exhaustion forces a temporary break in the engagement. Such ferocity is related to the breeding strategy of this species, in which the male has exclusive responsibility for raising the young. Somewhat paradoxically, a key element of the paternal duties is diligent and delicate handling of the hatchlings.

The Siamese fighting fish, *Betta splendens,* lives in ponds and small, sluggish streams, canals, and ditches throughout much of Thailand and eastern Kampuchea (Cambodia). Unable to obtain sufficient oxygen through its gills, and thus dependent on atmospheric air for survival, the fish periodically rises to the surface, expels a bubble of impure air, and gulps a fresh mouthful, which is utilized through an auxiliary respiratory apparatus.

In the male, bubble blowing serves as more than a way of ridding himself of bad air. A mucous secretion strengthens the walls of the bubbles, giving them a longer life and keeping them in a relatively compact mass that is the basis of the bubble nest constructed by the male at the time of breeding.

The fish spawn at all times of the year. If the male accepts an approaching egg-laden female into his territory, an intricate courtship and breeding ritual follows. Resplendent in the bright colors that were triggered by the process of establishing a territory, building a nest, and accepting a mate, the male curves his body into a C shape into which the drabber female snuggles. Stimulated by the embrace, she releases from 400 to 500 eggs over a period of several hours.

The partners swim after the downward-drifting eggs, catching them in their mouths. Each egg is carried to the nest floating on the surface and then spit into the mass of bubbles. The female's role in breeding ends at this point, and she is chased away by the male, who maintains a constant guard over the rapidly developing eggs.

After hatching, the young huddle under the remnants of the bubble nest for safety. Those unable to maintain their position are retrieved by the watchful male, who feeds actively during this time but, unlike many other fishes, refrains from making a meal of his offspring. He has ample opportunity to do so because not only are the fry fairly stationary in their sanctuary, but the male repeatedly takes them into his mouth and then blows them out accompanied by new bubbles. This seems to insure that the hatchlings receive sufficient oxygen and also repairs rents in the nest.

The young live for a few days on the nourishment provided by absorption of their yolk sacs, followed by a period of ten to twelve days during which they prey on microscopic crustaceans. They are then developed enough to begin a life of voracious predation on mosquito larvae.

The fish have been kept in captivity in Southeast Asia for hundreds of years, not for their potential use in mosquito control, but for their ferociousness. Thais and Cambodians have selected strains of Siamese fighting fish for aggressiveness and stamina. These short-finned varieties are pitted against each other and will fight for hours until one of the combatants is vanquished. Wagering on the outcome is the name of the game, and the sport is so popular that some residents of Bangkok make a living by raising mosquitoes. The larvae are sold as food to owners of fighting fish.

Siamese fighting fish were introduced to Europe in the 1890s for the aquarium trade and reached the United States a few years later. Fish fanciers on the two continents have concentrated on developing strains with a brilliant variety of colors and long, crepelike fins. The photographs on the following pages demonstrate their success.

Fred Hartmann

Spitting bubbles, a breeding male constructs a nest. The compact mass floats on the surface, held together by a thin film of mucus.

Photographs by Jacques Six

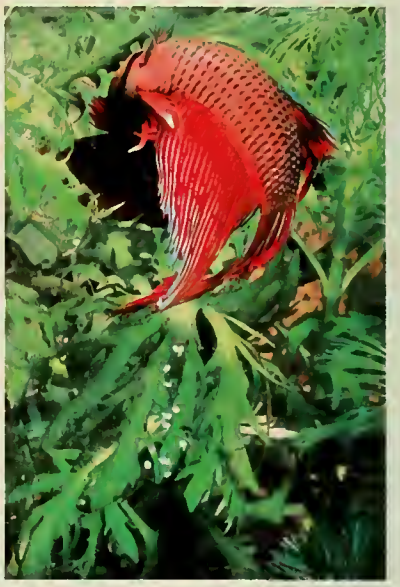
Stationed beneath the bubble nest he has assembled, a brightly colored and highly territorial male is approached from below by a duller-hued female who is ready to spawn.



Accepting her as a mate, the male bends into a C shape. The female slips into the curve of his body, and they begin their mating embrace.



Stimulated by the contact, the female releases the first batch of 400 to 500 eggs, which are fertilized by the male's milt.

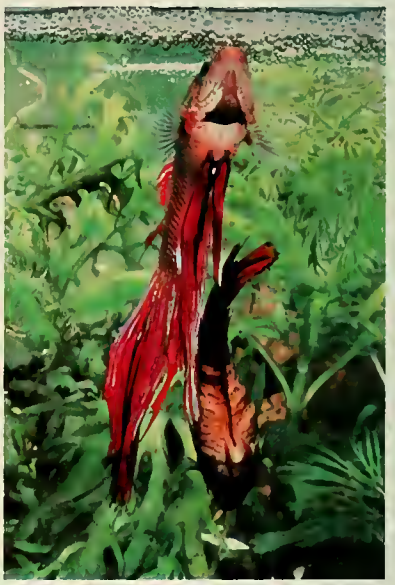




Unwrapping himself from the embrace, the male chases the eggs, which are drifting toward the bottom.



The female is still releasing eggs as the male busily gathers them up in his mouth one at a time and transports them to the nest.



The male spits an egg into the nest as his mate chases after others still loose in the water. When all the eggs are in place he will chase her away. Hours later, right, the male mouths the developing fry, forms new bubbles around them to insure that they are sufficiently oxygenated, and repositions them in the nest.



George Edwards: Depictor of "Nondescripts"

A leading zoological illustrator of the eighteenth century won acclaim for his keen observation, remarkable fidelity, and publishing firsts. Oblivion followed

by Sarah Blaffer Hrdy

"It is exceeding hard to discover what Truth is in a World of Falsehood and Controversy, where all of us suck in Error with our Milk. Is not the great Part of the World taught to believe, that their Senses are Lyars? . . . but it is a fixed and firm Article of my private Faith, that God hath given us our Senses as a Touchstone of Truth and that whatever Writing, Tradition, or bold Assertion, advances any Opinion, that directly and flatly contradict the Senses, which God hath given us to judge by, are absolute Falsehoods and ought to be rejected by all Mankind."



The Little Indian King-Fishers (Indian small blue kingfisher)

In these words, one of the foremost zoological illustrators of his day, George Edwards, summed up his personal philosophy. A small-town English boy who was only serendipitously led to a career in zoology, Edwards believed that we are reared ingesting falsehood right along with our mother's milk. For a period that spanned the greater part of the eighteenth century, he did his best to remedy the situation by producing illustrations so accurate and handsome that his contemporary Linnaeus referred to them as "an ornament to the age in which we live." In seven volumes published between 1743 and 1764, a host of animal species were described for the first time by eyes self-consciously free of misperceptions. In recompense for these labors—as Edwards himself foresaw—he gained almost total obscurity.

Although Edwards had a large following during his lifetime, his contributions were quickly eclipsed by rapid advances in scientific illustration and taxonomic classification. In some cases, however, a century or more elapsed before Edwards's observations on the behavior of various species could be confirmed by field biologists. By that time his name was long forgotten and his work locked away in rare book rooms.

The Large Green And Spotted Lizard (eyed lizard)





At the time of Edwards's birth, in 1694, commerce was one of the few routes to advancement for a young person from a background that today might be thought of as lower middle class. For seven years, the young George Edwards learned business in the home of a London merchant. Halfway through his apprenticeship, Edwards's life was profoundly altered by the happenstance of where his bedroom was. An eminent physician, a relative of Edwards's master, died and bequeathed to the London tradesman a vast collection of books. These were stored in a spare room next to the bedroom assigned to Edwards, and for almost three years the young man spent all of his evenings—and sometimes the greater part of his nights—reading, with the result that he developed

> a very disadvantageous Turn of Mind, for I could not think of confining myself to Business, which probably would have raised my Fortune in the World. My Head was filled with a confused Mixture of Voyages, Travels, Astronomy, Experimental Philosophy, Natural History, Painting, Sculpture, and many other Things which gave me an Inclination to visit Foreign Parts, in order to convince my Senses of some Things, which yet had only been conceived by the Mind.

When his apprenticeship expired in 1716, the twenty-two-year old gave up any hope of a commercial career in order to see the world. Between the years 1716 and 1720, a footloose Edwards visited Holland, Norway, and France, seizing every opportunity to inspect the foreign landscape, often at considerable risk. The countryside was rough and local inhabitants unaccustomed to the idiosyncracies of bird watchers. In Norway, during Charles XII's siege of Friedrichstadt, Edwards was captured by Danish soldiers who took him for a spy. He later adopted a beggar's disguise to escape the depredations of highwaymen. This innocent deception nearly backfired, however, when one of his field trips coincided with a French edict to secure all vagrants and ship them off to America to help settle the Mississippi valley. Edwards narrowly escaped by pretending to comply, "which [later] gave me the Opportunity to give them the Slip." This escapade marked the end of his travels, since "by dabbling a little in the Grand Game of Mississippi . . . I was disabled from continuing so long in France as I designed."

While traveling, Edwards made sketches of what he saw. Back in England, he devoted himself full time to a new career as an artist. He later wrote, "I applied myself pretty close to drawing and colouring, and what principally pleased me was copying strictly after Nature; and amongst Natural Objects, Birds happened at first to fall most my Way, and getting a few Drawings of these together, raised in me an Ambition to obtain a Collection as great as was in my Power." He apparently sold enough drawings to support himself, although since he had no formal training, his first, self-taught efforts were probably fairly crude. Nevertheless, he gradually acquired a number of promoters. Among his early patrons was Sir Hans Sloane, physician-naturalist, president of the College of Physicians, and one of the great collectors of his day.

In 1733 Sloane recommended Edwards for the position of librarian of the college, a post that he was to occupy throughout most of his long career. This post meant not only financial security and an apartment, but access to one of the finest natural history libraries of the day, and, perhaps most important, entree into the private collections of a privileged class obsessed with the assemblage of rare creatures. In Sloane's gardens alone, Edwards could observe at firsthand reindeer from Lapland browsing amid porcupines and chipmunks, African



The Sea Bat And Pyed acarauna (batfish and rock beauty)

he Maucauco (ring-tailed lemur)

crested cranes, a wide variety of Chinese birds, and a wolverine from Canada that he was the first to draw and describe for publication.

Exotic menageries and collections of curiosities were *de rigueur* for any sophisticate who aspired to be a person of learning. Creatures from all over the British Empire could be found in the gardens of courtesans and socialites or as mascots behind the counter at local taverns and coffee houses. One of Edwards's loveliest drawings, of the zebra-striped hoopoe (*Upupa epops*), was made at Slater's coffee house in Chelsea. Sea captains and privateers returned to England with clinging and slithering cargoes, many earmarked for Edwards. A cage full of handsome yellow-headed linnets came to Edwards from a captured Spanish galleon. He again prospered from piracy when Capt. Laurence Shirley (later the fourth earl of Ferrers) captured from a French prize a number of birds intended for Madame Pompadour.

The earliest records of zoological collections in far corners of the earth are often due to Edwards's scholarly habit of carefully noting the source and, when possible, the locale where collected for each of his specimens. Edwards kept a number of pets himself, including a colony of ring-tailed lemurs from Madagascar. He availed himself of a wide range of sources, some exotic and some closer to home. During a particularly harsh London winter, for example, he found a wild swan on sale in the London Market, took it home, and drew it.

The outrageous fashionability of collecting rare animals was a professional windfall for the man who strove to represent living creatures in fastidious detail and who prided himself on being the first to illustrate members of a given species—to draw what he referred to as "nondescripts." In 1743 Edwards published the first volume of his *Natural History of Uncommon Birds*, illustrating fifty-one species of birds and two mammals, many of which had never been described. Three more volumes followed between 1747 and 1751. By the fourth volume, Edwards was feeling his fifty-seven years and wearily imagined that this would be his last. Considering it the most perfect of his productions on natural history, he dedicated it to God.

Fortunately, Edwards's personal decision to close shop did not stem the flow of living, stuffed, and bottled creatures that were sent to him from all over the world by the energetic medley of aristocrats, pirates, hunters, amateur bird watchers, and fellow naturalists who had come to admire his work. To accommodate them, and in part to repay his suppliers, Edwards embarked on what he considered a miscellaneous series, the gorgeous three volumes entitled *Gleanings of Natural History*, which were published between 1758 and 1764. The volumes combined Edwards's drawings, descriptive texts, and essays on a variety of topics, including bird migrations, tidal waves, and recommendations on social policy. These essays were later combined and published as a single volume. After his death, a separate volume on the study of fossils was also published.

In retrospect, several features of the *Gleanings* and the *History of Uncommon Birds* stand out on the landscape of British natural history in the eighteenth century. First, of course, was Edwards's conviction that "what is well done after nature itself will always be valuable." Artistic method became the servant of his determination to describe his subjects with utmost accuracy. With pride, Edwards reminds readers that most of his subjects have been drawn either from life or from actual specimens. Body measurements and weights were included



The Hen Bustard (great bustard)

The Albatross (albatros


G. Edwards
1745



This Animal is callid AL JERBUA, *or* JERBUA, *and is figurd & describd in Del Tesoro Britannico Delineato e D*
critto da Nicola Francesco Haym Romano Vol.2d pa.124.125. The living Animal from which this was de
of its natural Size is now the Property of Mr. Scarlett, Opician, by St. Anns Church, Westminster. Mr. Bles
Librarian to the Inner Temple, had also lately one of them living: It is remarkable that it hops like a Bird
on its hinder Legs, never setting its fore Paws on the Ground, but generally hides them in the Furr under its Throat

The Gerbua (Egyptian jerboa)

in the text where possible. Almost all of the copper plates in Edwards's later work were etched by him, lessening the likelihood of error. Only four of the illustrations in the *Gleanings* were farmed out to hired engravers. To insure accurate depiction of the subject's coloring, he provided a model drawing for each species and personally supervised the coloring of each print. In anticipation of his death, his correctly colored models were deposited in the British Museum, in the Royal College of Physicians, and with his publisher, Robson, so that the originals could be consulted in the production of subsequent editions of his work.

Despite these precautions, Edwards could do little to insure accuracy among his imitators. While he drew from life, many others simply copied Edwards; some artists, such as the American painter-clergyman Jonathan Fisher, virtually built their artistic careers on the practice. The imitators ranged from such eminent figures as the French naturalist Buffon to a host of anonymous craftsmen who decorated the chinaware and fancy cloth of the day with Edwards's designs. The famous Chelsea Porcelain Factory issued a whole series of figures based on Edwards's birds. Predictably, his chief grievance with such copies was that they were "generally so miserably lamed and distorted that the judicious Part of the World can form but a mean Opinion of the Work from which they are plounder'd."

The painstaking efforts that Edwards made to insure accuracy in his own drawings and written descriptions, as well as his meticulous documentation of sources, made him intolerant of naturalists with lower standards. Scarcely a page in the *History of Uncommon Birds* passes without some disparagement of his countryman Eleazer Albin. "Albin on birds need not be examined, seeing his figures [of the bustard] are copied from the Paris Academy, and his description from [the early British ornithologist] Willoughby." Although sensitive to the concept of priority, if a given species had been previously drawn by Albin, Edwards would sometimes continue to regard it as technically a "nondescript" because he found "so much inaccuracy."

For the American-based ornithologist Mark Catesby—Edwards's close friend, provider of specimens, and the fellow artist who taught him how to etch drawings onto copper plates—Edwards reserved his highest praise: "I should not have presumed to republish anything that was directly the same with what has been published by Mr. Catesby, because I know myself to be not capable to add any Amendments to what he has done." Edwards also considered "very useful" the work of the French ornithologist Brisson, whose book, *Ornithologie,* was published in Paris in 1760. Even these favorites, however, did not completely escape critical appraisal. Edwards felt that "as will happen to every Compiler that hath not long and carefully studied the Subjects he treats of," Brisson suffered from "frequent Repetitions of the same identical Species of Birds under different Names." His single criticism of Catesby was that his friend's lavishly illustrated coffee table productions would be inaccessible to the ordinary reader.

Edwards had an educator's concern for communicating accurate information to the general public. An unusually fine but "very pompous" natural history published in Amsterdam by Albertus Seba in 1734 was largely dismissed by Edwards, who illustrated in his own works many species presented by Seba because he considered that this "great and very expensive work" was unlikely ever to be read by his countrymen. In the interest of accessibility, Edwards published all of his work in English and included in each volume the entire text translated into French. He did his own engraving to reduce the price of his work and insure accuracy. Occasionally, because of the size of a subject, illustrations had to be greatly reduced. In these cases, Edwards would artfully include as part of the composition an inset showing a life-sized claw or feather or a detail of the head or body. In the case of his rhinoceros, a small inset to the left of the body illustrates the fleur-de-lis shape of the animal's extruded penis.

Also remarkable was Edwards's concern with the attributes and adaptations of animals that went beyond typology. In addition to size, appearance, and detailed observations on sexual dimorphism, he noted, wherever possible, the origin of his subjects, the habitats they lived in, their diets, behaviors, and temperaments.

To Edwards must go the credit for such ethological coups as publishing the first accounts of the origin of the extraordinary booming sound of the ruffed grouse, which the bird makes by beating its wings at high speed; of prey catching and meat eating among various prosimians and New World monkeys; and of paternal care of offspring among marmosets. Marmosets were common in some European circles at this time, when the fluffier species of these miniature South American monkeys were worn as live adornments to scurry in and out of billowing sleeves and bouffant hairdos.

Edwards paid careful attention to what he saw and continually tested current notions against observations of the natural world. In his short essay on the disappearance of birds in winter, for example, Edwards laid out three views current in the eighteenth century and weighed the evidence in favor of each. One hypothesis, dating back to Aristotle and Pliny, held that birds used their short legs and strong claws to spend the winter hanging upside down, clustered together in mines and grottoes and in cliffs beside the sea. More widely held was the view that birds, and in particular swallows, retired underwater to sleep out the winter. Of this preposterous suggestion, Edwards wrote that it was "at first Sight too amazing and unnatural to merit Mention, if it was not that some of the Learned have been credulous enough to deliver, for Fact, what has the strongest Appearance of Impossibility." Edwards's main objection, which he considered conclusive, was the lack of any avian apparatus for breathing underwater. He discredited the first hypothesis, which "would make Sleepers" of birds, by point-

ing out that such hibernating birds were never encountered.

Rejecting the first two hypotheses, Edwards leaned toward the third opinion, that migrating birds "move nearer the Sun, where they can find a Continuance of their natural Diet, and a Temperature of Air suiting their Constitutions." He cited observations of European swallows to support this interpretation. Proponents of the "sleeper" hypothesis had suggested that birds "retire to Holes under Ground, hollow Trees, etc." because they are "so fat they cannot fly at the times they disappear." Edwards argued instead that such fatness was actually "a providential Provision to enable them to take a Flight of many Days without being quite exhausted and spent."

I have long been puzzled by how this man—who to all appearances was utterly conventional—was able to look on the world with so fresh a vision. The only answer that has suggested itself to me is a curious one: Edwards's humility. So modest was this man about his own assumptions and education that he took almost nothing for granted except what he could see with his own eyes. This is not to say that Edwards underestimated his own worth or failed to recognize the high quality of his illustrations. His writings contain realistic appraisals of his merits relative to those of his predecessors. Nevertheless, piety and humility pervade his writing:

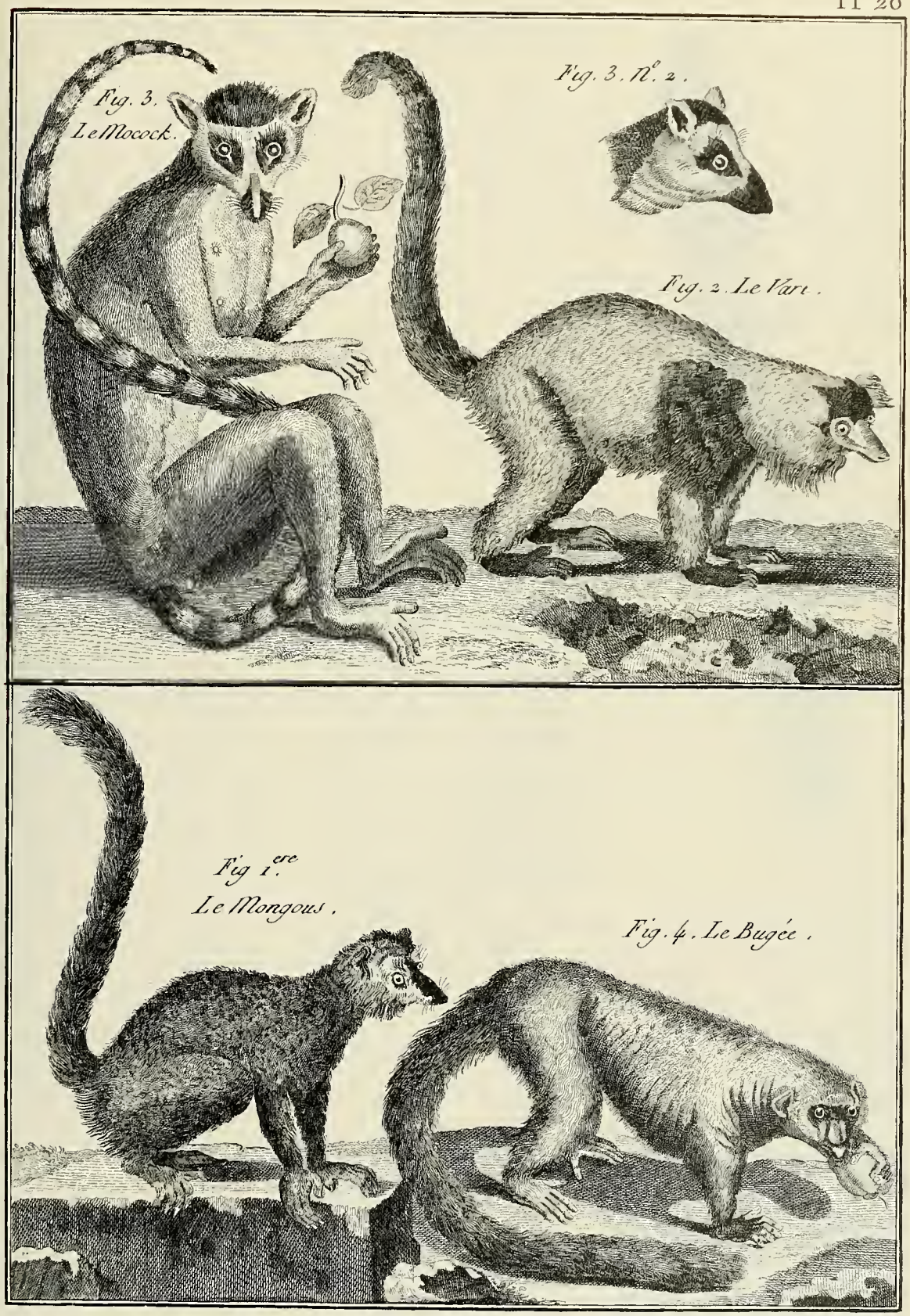
> In the course of my works, I have generally had the advantage of working from real nature, many of my subjects being living and in high perfection, and others well preserved in order to be imported to us from foreign parts: and, if my figures fall short of nature, as they certainly must, it is not for want of care in me, or infinite difference between the Great Creator of natural productions, and the presumptuous weak creature, who dared to essay an imitation of the works of the Omnipotent. Sometimes, being for a moment thoughtless of the Great Source of nature, I have vainly fancied my faint imitations of her works in some degree complete; but, on the least recollection, a slow, aweful, majestic voice seemed to reprove me thus: Vain and presumptuous wretch! dost thou imagine, thy faint endeavours can bear the least comparison with the works of Him that created thee and all things?

In 1744 Edwards became a candidate for election to the Royal Society, the most prestigious intellectual "club" of the day. The routine procedure was to read out loud the names of nominees at ten consecutive meetings before taking a vote. A week after he was nominated, Edwards inexplicably withdrew. We can only speculate as to the reasons. Perhaps he could not afford the dues. In a catalog detailing the natural history items sold from the estate of the late earl of Bute, a meticulous buyer wrote in sepia ink beside each purchase what was bid for it. As late as 1794, when the auction took place, an Edwards engraving could be bought for a shilling or two. My own hunch, however, was that Edwards did not feel himself worthy. Six years later Edwards was awarded the gold medal donated by Sir Godfrey Copley, which the Royal Society presented annually to the author of a new discovery in art or nature. A few years after that—perhaps convinced at last of his eligibility—he accepted election to the Society.

Edwards's strong sense of personal modesty was probably intensified by the social distance that separated him from his associates. He reminisces how, after his old patron and friend Sir Hans Sloane retired to his estate in Chelsea, "he requested as a favor to him (though I embraced his request as an honour done to myself) that I would visit him every other week, in order to divert him for an hour or two, with the common news of the town . . . and news of the Royal Society." Edwards was in fact with Sloane the day he died. But despite their intimacy, barriers of class and remembered patronage could never be completely erased. For each visit, Sloane carefully reimbursed his friend for his traveling expenses.

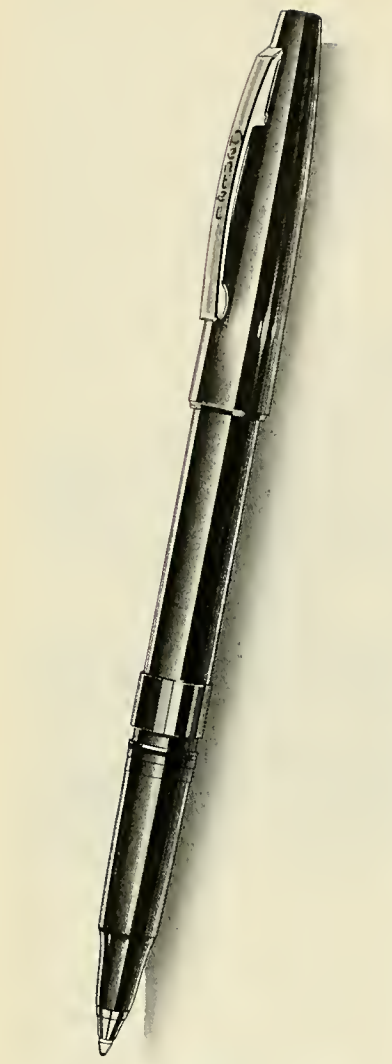
Virtually no clues exist to tell us what Edwards himself thought of his social circumstances. Apart from the account of his early education and young manhood, he makes no mention of his family. Robson tells us that at his death of cancer at the age of eighty, Edwards, who never married, bequeathed his modest fortune to his two spinster sisters, who lived together. There are no hints in Edwards's record of any life beyond the one he describes for us: a career spanning sixty years, singlemindedly dedicated to the accurate representation of the natural world. We are left to wonder what motivated such a man. Was he impelled by an obsession (as Edwards himself feared in moments of self-doubt), exalted by reverence for the Almighty's creations (as he sometimes hoped), or did he modestly persevere in the diligent application of his talents simply because it was a contribution he felt he could make?

Whatever the motivation for his labors, its fruits are eloquently described for us by Linnaeus. Although the two never met, there was enormous mutual admiration between them. Linnaeus had some of Edwards's engravings on display in his study and used his descriptions to identify new species. Edwards, in turn, was one of the first naturalists in Britain to recognize the importance of Linnaeus's work. In later editions of Edwards's volumes, a list was appended by Linnaeus giving the Latin names for all the species depicted. In a letter to his colleague, Linnaeus wrote, "Nothing can more conduce to the advancement of solid natural knowledge than such beautiful and excellent figures, accompanied by such exact descriptions." In congratulating Edwards for "the beautiful and innumerable rare birds, beyond what any other person has seen, or is likely to meet with . . . in which nothing is wanting to the birds but their song," Linnaeus optimistically, and euphorically, predicted that "even these will sing your praise, as long as birds or men endure." But, as usual, Edwards's own vision was more accurate than that of his contemporaries when he modestly ended the Preface to volume one of his *Gleanings of Natural History* by reserving judgment on what the fate of his work should be. "I cannot pretend to judge," he wrote, "but I submit it to the Critics, Correctors, Reformers, Translators, Regravers, and lastly to obscurity and utter oblivion." □

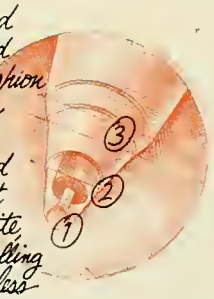


Copies of Edwards's ring-tailed lemur, cotton-top marmoset, yellow-handed marmoset, and common marmoset, by Buffon.

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Asteroids are shown by new research to be rocky bodies, larger and darker than expected, and composed of several types of material

The asteroids, or minor planets, are faint starlike objects that slowly traverse our night sky. They are small planetary bodies orbiting the sun between Mars and Jupiter in a ring referred to as the asteroid belt. Their nature was unknown right up to the early 1970s, but in the past five years powerful new methods have been applied to their study, revealing an astounding amount of new data. The asteroids are about 30 percent larger than early estimates suggested, and the first detailed spectra have indicated at least half a dozen different surface rock types. A distinct trend in planet type is found on crossing the main asteroid belt, and data from several different investigations suggest that the belt has suffered many destructive collisions during its history. The Trojan asteroids, which share the orbit of the planet Jupiter, are exceptionally dark bodies probably composed of primitive material of very great age.

During the eighteenth century, a number of astronomers had noted and speculated about the apparent gap in the planetary system between Mars and Jupiter. Plans were afoot at the turn of that century to organize visual searches for the missing planet but these were forestalled by the Italian mathematician and astronomer Guiseppe Piazzi, who discovered the first minor planet, 1 Ceres, on January 1, 1801. The search group later added 2 Pallas, 3 Juno, and 4 Vesta by 1807. A fifth minor planet was added in 1845 and 300 were known by 1890. The introduction of photographic methods in 1891 opened the floodgates and hundreds of faint asteroids were rapidly located.

An asteroid is identified by its orbit. Once this is known accurately its position at any time in the past or future can be computed. Early computations involved lengthy and tedious work by hand and many asteroids were lost because of limited computing capacity. Only the advent of the high-speed electronic computer in the past twenty years has enabled astronomers to keep track of all the bodies with well-determined orbits. After receiving a preliminary designation in order of discovery, asteroids are given a permanent number when their orbit is accurately known. The latest is minor planet 2,042, numbered at the end of 1977. Once numbered, the original discoverer then has the first option on naming the asteroid. In addition to the more than 2,000 numbered asteroids, there are about 2,000 others that have either been lost or have not yet had their orbits accurately determined.

The bulk of the known minor planets, perhaps 95 percent, lie in the main belt and have periods of from two to six years. Their orbits are ellipses of low eccentricity, and the asteroids at the well-defined inner edge of the belt are strongly concentrated in the solar system plane. The scatter of the orbits, especially in inclination, increases on moving outward through the belt and the outer edge is rather diffuse.

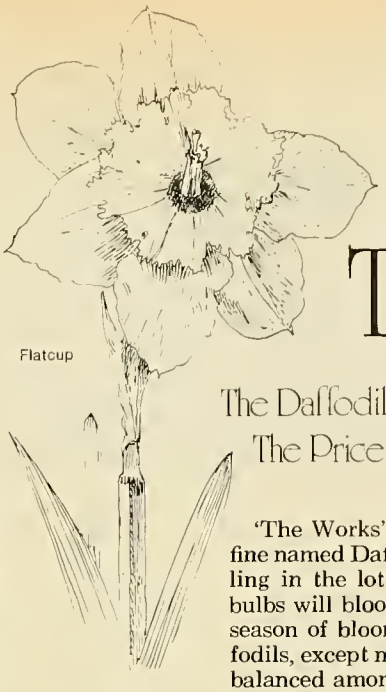
A survey by the McDonald Observatory in Texas in 1958 obtained statistical data on asteroids brighter

by Keith Hindley

than magnitude 16, and the Palomar-Leiden survey in 1970 extended this down to below magnitude 20. These surveys indicate that the total number of minor planets brighter than magnitude 21.2, corresponding to a diameter of about one mile, is some 480,000. The total mass involved here is about 0.0004 earth masses, or about twice the mass of the largest asteroid, 1 Ceres. That is rather a small total and explodes the myth that the minor planets are the fragments of a terrestrial-style planet that disintegrated.

Distinct gaps occur in the frequency distribution of asteroid orbit sizes. These Kirkwood gaps, named after their discoverer, occur at periods that are precise fractions of Jupiter's orbital period—so-called commensurabilities. The gaps are due to gravitational perturbations by Jupiter, which recur repeatedly at the same orbit position for asteroids with commensurate periods. About ten such gaps have been swept clear by Jupiter. If the orbital elements of the minor planets are freed from the effects of long-term perturbations, then a number of distinct groupings of the orbits stand out. Called Hirayama families, these groups may each be the scattered fragments from a disruptive collision between two large asteroids at some time in the past. Ten main families are recognized and a number of diffuse ones suspected. In all, about one-third of all known asteroids are members of such family groupings.

With accurate orbits for so many asteroids available, a detailed model of the main belt can now be constructed. Are the minor planets mainly bits that have always existed much as they are now or are they

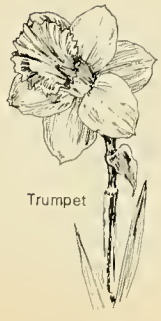


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principally pieces resulting from the destructive collisions of a few large minor planets? Detailed computations during the past few years imply that the asteroid belt is indeed in a highly fragmented state. The belt appears to have originated as a system of perhaps fifty large bodies in the 50- to 500-mile size range. These accreted during the formation of the solar system and began at once to suffer mutual collisions. This hypothesis suggests that only a few of the larger asteroids are still intact bodies from the original distribution. The notion seems to be borne out by the periodic light variations of most asteroids. The constantly changing light output is most likely due to the rotation of irregularly shaped objects, fragments from collisions. The Viking spacecraft photographs of the Martian moons Phobos and Deimos demonstrate the appearance of typical irregular asteroidal bodies. The shapes can be extreme, as in the case of 433 Eros, which is a spindle-shaped rock about 5 by 10 by 20 miles that tumbles along its orbit with a period of about 5.3 hours.

Up to 1970, the only available data on asteroid diameters were from direct measurement of the tiny disks of the four largest bodies using some of the world's largest telescopes. With image sizes only just above the limit of resolution, these diameters were at best estimates of size. Diameters for smaller bodies were rough estimates based on their brightness relative to the measured four. In 1970, however, astronomers applied two completely new approaches to asteroid diameters. The first involves a study of the polarization of sunlight reflected by an asteroid at different phase angles. Polarization becomes negative for small phase angles but rises linearly at angles greater than about 15°. Laboratory studies of powdered terrestrial, lunar, and meteoritic rocks show that the slope of this rising branch is closely correlated with the albedo, or reflectivity, of the sample. Moreover, the relation is completely independent of mineral grain size or other physical effects. The absolute magnitude of an asteroid, coupled with the albedo deduced in this way, immediately gives the minor planet diameter.

The second technique makes use of asteroid brightness in both the visible and the infrared. The visible brightness is light reflected by the asteroid; the infrared brightness arises from light absorbed and subsequently reradiated as heat. The ratio of these two yields the albedo, which again gives the asteroid size. These two powerful, independent new techniques are both based on firmly established theory. Studies of the brightest asteroids require only modest astronomical telescopes. The use of very large telescopes enables hundreds of asteroids to be studied.

The initial results from both methods were consistent but startling. Deduced albedos vary from 1.9 percent for 95 Arethusa to 37.7 percent for 44 Nysa. In general, though, the 190 asteroids studied so far divide into two main groups. The low-albedo group was unexpected and is probably produced by a carbon-rich surface material. The other group appears to have albedos corresponding to siliceous minerals.

The asteroids studied so far tend to be the brightest ones that either have high albedos or are situated in the inner part of the asteroid belt. If these effects are allowed for, it is clear that carbonaceous asteroid surfaces are the commonest type and become more frequent moving outward through the belt. At the inner edge, about 50 percent are dark bodies but this figure steadily increases to fully 95 percent at the outer edge. As a result, when the dozen largest asteroids are listed, the few large bright objects are joined by many unfamiliar dark distant objects. There are now 112 minor planets with diameters of fifty miles or more and, after selection effects have been allowed for, it is clear that 88 percent of these are carbonaceous. One serious consequence of these results is a much larger concentration of substantial bodies toward the outer edge of the belt than previously suspected. The maximum density of the belt must therefore lie somewhere beyond three astronomical units (AU).

During their history the minor planets may or may not have suffered internal melting, depending on the amount of radioactive material present in each body. The larger the body, the more likely melting would have been. If the whole planet melted and differentiated, then a metallic core with a small layer of stony iron material would be encased in a thick basaltic outer shell. Partial melting is, however, more likely and would lead to a small metallic body at the center of a large, stony iron core, overlain with silicates and topped with a thick layer of unaffected primitive carbonaceous materials. The spectral data show that there are many reddish asteroids with siliceous surfaces in the 25- to 125-mile size range and some investigators have suggested that these are the stony iron cores of differentiated asteroids that have lost their thick mantles in collisions. The hard core would not be so easily fragmented. These bodies prevail in the inner part of the belt where collisions would have been more common. Probably the only fully differentiated asteroids that still survive intact are 1 Vesta

The Twelve Largest Asteroids

Number	Name	Diameter (miles)	Albedo (percent)	Mean Distance from Sun (astronomical units)	Surface Type
1	Ceres	620	5.4	2.77	carbonaceous
2	Pallas	375	7.4	2.36	peculiar carbon
4	Vesta	330	22.9	2.36	eucritic
10	Hygeia	280	4.1	3.15	peculiar carbon
31	Euphrosyne	230	3.0	3.16	carbonaceous
704	Interamnia	215	3.3	3.06	carbonaceous
511	Davida	200	3.7	3.19	carbonaceous
65	Cybele	190	2.2	3.42	carbonaceous
52	Europa	180	3.5	3.10	carbonaceous
451	Patientia	170	2.6	3.06	carbonaceous
15	Eunomia	170	15.5	2.64	siliceous
16	Psyche	155	9.3	2.93	metallic iron

and possibly a few other bright objects.

The Apollo and Amor group are asteroids traveling in eccentric ellipses that carry them sunward among the terrestrial planets. Many pass close to the earth and more than twenty are now known. Surprisingly, this group contains the only asteroids with spectra closely resembling the normal chondritic meteorites—the commonest type of meteorite fall. These bodies may have originated as small debris deflected from the main asteroid belt or they may be the degassed extinct rocky nuclei of short-period comets. A number of these objects could be reached by spacecraft relatively easily. They offer an opportunity of manned exploration using only modified Apollo equipment.

The Trojan asteroids, named after the heroes of the two camps in the Trojan War, exist in fairly stable libration, or oscillating, orbits with Jupiter. They occupy one corner of an equilateral triangle with the sun and Jupiter, on either side of the giant planet, but can oscillate considerably to either side of these mean positions. Up to 1974, only sixteen were known, but a recent survey has revealed several thousand faint Trojans. These minor planets are remarkable in having exceptionally dark, rather reddish surface materials unlike any of the main belt asteroids.

It is now clear that primitive materials that condensed directly from the primordial solar system gas and dust cloud may still survive intact in some of the minor planets. Manned and unmanned missions to recover samples from these bodies are now under active discussion. Of particular interest would be rock from the surfaces of the Trojan or carbonaceous main belt planets. The asteroids may turn out to be the Rosetta stones of the solar system with their primitive materials revealing a vast amount of fresh information on the early days of solar system history.

Keith Hindley, who has a doctorate in organic chemistry, is a science writer and head of the Meteor Section of the British Astronomical Association. This article first appeared in New Scientist, *London, the weekly review of science and technology.*

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Celestial Events

by Thomas D. Nicholson

Sun and Moon The sun moves through the stars of Aries from the beginning of May until the 14th, then moves into Taurus, where it remains until late June. By mid-May, it is so far north that the duration of daylight (14 hours and 23 minutes) is near its maximum for the year. The moon is a morning crescent in early May (and again in early June). The evening crescent will appear near Venus about the 8th or 9th of May, and the moon will remain an evening object until the last week. The evening crescent will also show up about June 8, again near Venus.

Phases in May are new moon on the 6th, first-quarter on the 15th, full moon on the 22nd, and last-quarter on the 28th. New moon will recur on the 5th of June, first-quarter on the 13th, full moon on the 20th, and last-quarter on the 27th.

Stars and Planets May is a great month for evening planets. Venus and Jupiter are in the west at sundown. Venus, the brighter, will appear first. In early May, Venus is near the star Aldebaran (in Taurus), and Jupiter is higher to its left. Venus moves swiftly toward Jupiter, however, and the distance between them closes perceptibly from night to night. They come together on the 28th, and thereafter Venus is higher and to the left as they separate again.

While Venus plays "catch up" with Jupiter, Mars is doing the same with Saturn, higher and to the left in the evening sky. In early May, Mars is midway between Pollux and Castor (the twin stars of Gemini) and Regulus (in Leo). Saturn, meantime, is near Regulus, to its right and above—and brighter than—the star. Mars is moving left (east) much more rapidly than Saturn, closing the distance between them each night. It passes Saturn very closely on June 4, with Regulus still nearby. The moon adds to the group from May 13 to 15 and again on the evening of June 11.

May 5: The Eta Aquarid meteor shower (only 20 per hour, but often quite bright) reaches maximum.

May 8: The moon covers Aldebaran (an occultation) in daylight over much of northeastern North America.

May 8–11: The crescent moon is near Venus and Jupiter.

May 9: Mercury is at greatest elongation (distance from the sun) in the morning sky, but not well placed for viewing.

May 11: The moon is at apogee (farthest from earth).

May 13–15: The moon (near first-quarter) passes below Mars and Saturn (and the nearby star Regulus) on these evenings.

May 24: The moon is at perigee (nearest earth).

May 28: Venus is in conjunction with Jupiter and moves from right to left past it.

June 4: Mars is very close to Saturn and moves past it from right to left. Regulus is nearby to the left of the two planets.

June 7: The crescent moon is near Jupiter, perhaps our last chance to see the planet as an evening star in this cycle.

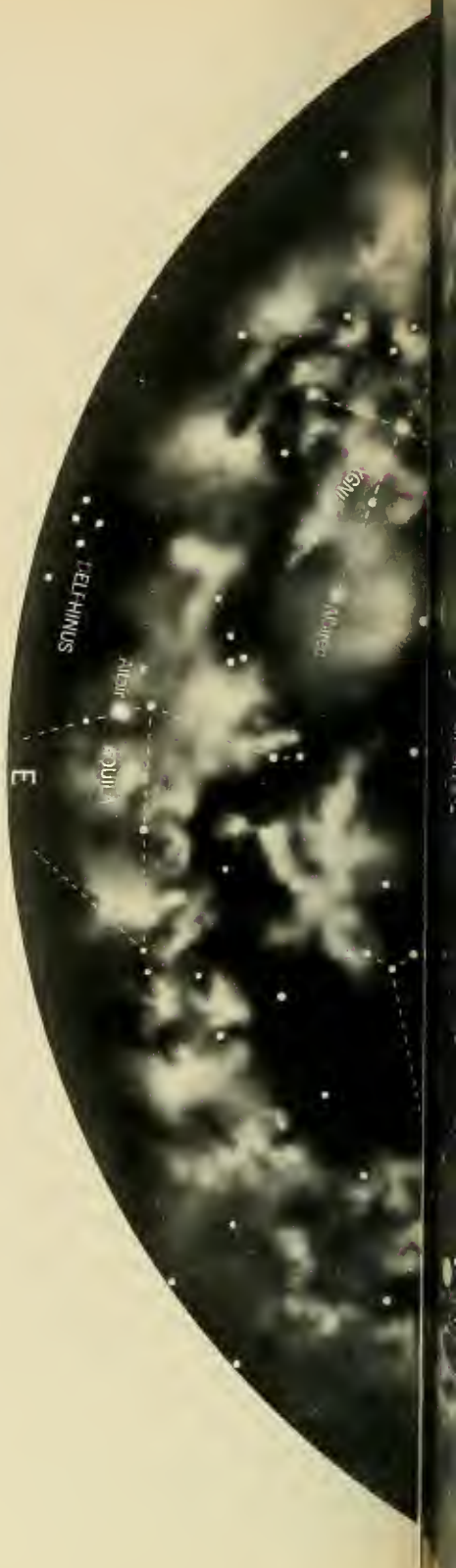
June 8: The moon is at apogee and passing south of Venus.

June 10: Venus is in conjunction with the star Pollux (in Gemini).

June 11: The moon is in conjunction with Mars and Saturn.

June 12: Mars passes very close (in conjunction) to Regulus (in Leo).

June 14: Mercury is in superior conjunction and enters the evening sky.



★Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:20 P.M. on May 1; 10:25 P.M. on May 15; 9:20 P.M. on May 31; and 8:25 P.M. on June 15; but it can also be used for an hour before and after those times.



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Silent Music and Invisible Art

by Edmund Carpenter

Unlike Westerners, the people of some cultures preserve their mysteries

To Western man, "silent music" is a contradiction in terms. "Invisible art" seems equally absurd, impossible, like the child of a barren woman. Even inaccessible art, although conceivable, seems somehow wrong, especially if deliberately inaccessible.

Roberto Matta, the surrealist, once put a painting on the six interior sides of a box, which he then sealed. And Walter de Maria proposed that a great cylinder be buried in a mountain overlooking Munich, its entrance concealed and never revealed. But Matta found no buyer and de Maria no backer. Art, we feel, demands viewers, and music, listeners.

I heard of an incident in the 1950s when a number of drug patients, many of them jazz musicians, were deprived of their instruments as punishment for some minor infraction of hospital rules. They sat about listlessly until a saxophonist picked up his invisible instrument and began to play silently; soon all the others joined in.

We call this mime, not music. Music is something we hear and share. Yet in many tribal societies, silent music is cultivated, even institutionalized. Singers sometimes plug both ears, converting sound into inner vibration. Or they may play small musical instruments inside their closed mouths.

Among North American Indians, silent music was the essence of the spirit quest. At puberty a boy went apart from his fellows and fasted for a time in the wilderness. If he was the proper sort, a spirit took pity on him, bestowing special powers, principally in the form of songs. These remained his personal property, never to be revealed, save just before death—and even then, not always.

In days of torment and doubt, he sang alone or silently to evoke his guardian's help, singing again when relief was granted. He also gave thanks by painting or carving images addressed to his guardian. These were hidden in inaccessible places—on cliff walls facing the sky or in forbidden caves facing darkness. They were never intended to be seen by the living.

Most were small, but a few—probably clan efforts—were immense, laid out on mountaintops or scraped from desert floors. One is reminded of the tale of the giant so huge he is invisible. From the ground nothing can be seen save meaningless lines of rock and earth. Only when seen from the sky do these lines become coherent. Now, from airplanes, we see what was once reserved for spirits.

In Canada, such earth sculptures are generally geometric, but along the Mexican-United States border, many are anthropomorphic, often depicting a male and female in coitus. Here, as elsewhere in the tribal world, such pairs probably represent the original tribal ancestors in "primordial copulation"; the monument thus represents the origin of the tribe and, by extension, the beginning of the world.

Such pregnant images were far too potent for mortal eyes. So were the contents of medicine bundles. Some medicine bundles were never opened, not even by their owners, who already knew what lay within. They had been entrusted with songs and formulas that now resided in fetishes concealed within the bundles. Any exposure, certainly any public exposure, could only diminish these powers.

We often think of communication as the transfer of knowledge from a knower to a nonknower. In a tribe, where all who are entitled to know, already know, such transfer is meaningless; the sharing of knowledge threatens both its ownership

A Haida Indian rattle, from British Columbia, circa 1840, became a mere blur when shaken and was hidden away when not in use.

Bullaty-Lome



and the very nature of that knowledge. Even when an object is brought forth publicly, it may be exposed in such a way it cannot really be seen. Among the Haida Indians, finely detailed rattles become mere blurs when rapidly shaken at crowded, firelit ceremonies. And among the Salish, when a spindle whorl is spun, its complex design disappears; when not in use, it is hidden away.

We Westerners treat art as public property. We display it with maximum clarity, in every possible medium, hoping for the largest possible audience. Our museums boast of crowds who come to see art and buy reproductions to take home.

American Indians treated art differently. Only a small part of their art was intended for public display. Clan and house objects were collectively owned, of course, but even they were displayed only on appropriate occasions, by appropriate persons, in appropriate ways, before select audiences. Residents in Indian villages spent their lives surrounded by hidden art; each saw only those treasures and heard only those songs he was entitled to see and hear.

Art inspired by visions was even less accessible. Private visions, like private songs, remained private.



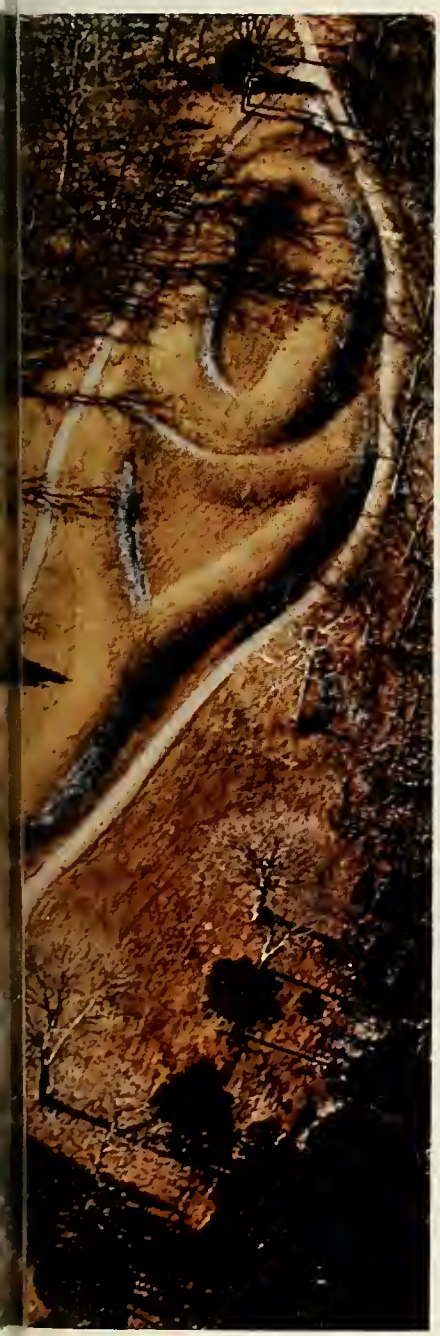
George Gerster, Photo Researchers

Public exposure diminished their power and made them vulnerable to theft, so they were carefully concealed.

Still, the possessor was tempted to hint about the visions. One method was pictorial shorthand, which produced abstract designs no stranger could decipher. Meaning was reserved for owners and when they died, was forever lost.

Among the Salish, according to anthropologist Wayne Suttles, "the vision was the unique experience of the individual," a source of skill and status. Its owner kept its exact nature secret, perhaps until old age. But he might hint at it in the winter dance, by word or movement. Any other representation was "vague, ambiguous, covert."

"Clearly," Suttles reported, "there were limits on the representation of visions ('guardian spirits'). In native theory, everyone (or every male perhaps) ought to 'train' and have a vision. But it was dangerous to reveal too much about it. If you talked about it, you could 'spoil' it; it might leave you or even make you sick or it could be taken away from you by an enemy shaman. Yet eventually you wanted others to know that you 'had something.' Probably all [ethnologists who have worked on the Northwest





Aerial photographs reveal old Indian sculptures that are almost indiscernible on the ground. The serpent mound, left, in Adams County, Ohio, is from the Adena Culture. The human figure, above, is on the desert floor at Blythe, California. The circular lines were made by modern vehicles.

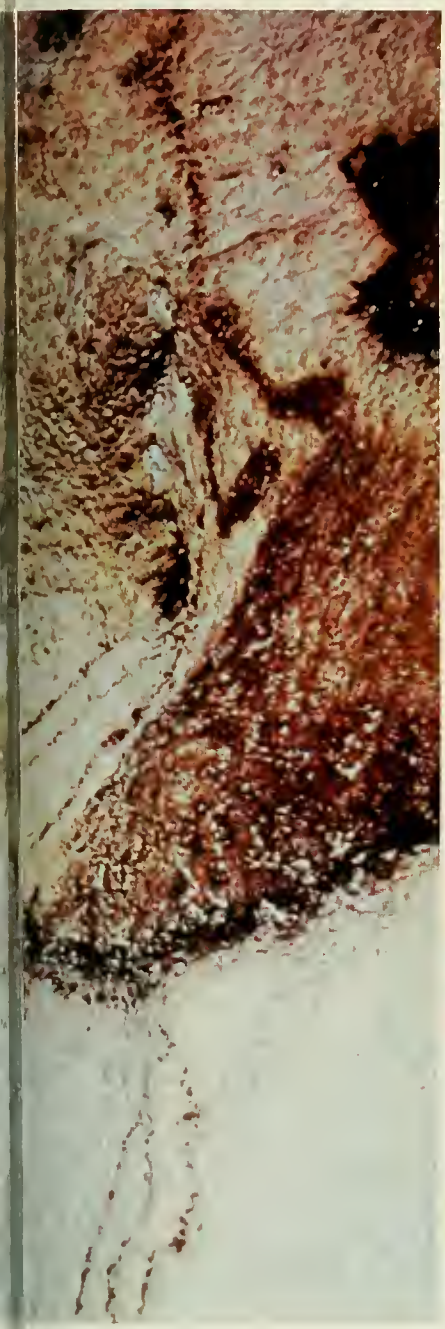


Coast] have heard hints and half-revelations about what people 'have.' [Being possessed] by a song at the winter dance is, of course, evidence that you 'have something' and the words of the song and the movements of the dance may hint at what it is. But it must be tempting to hint in other ways, though dangerous to go too far."

In some tribes, visions were never concretely represented. Elsewhere they were portrayed, but with constraints that affected artistic expression. One effect was a tendency to make images that were essentially *in-visible*. When you look outward, you see nature. But when you look inward, you see those invisible forces that underlie nature, including human nature. This is the *in-sight* of the blind seer. It is also the method of the modern scientist who insists that reality is not in appearances, but in the laws that govern them.

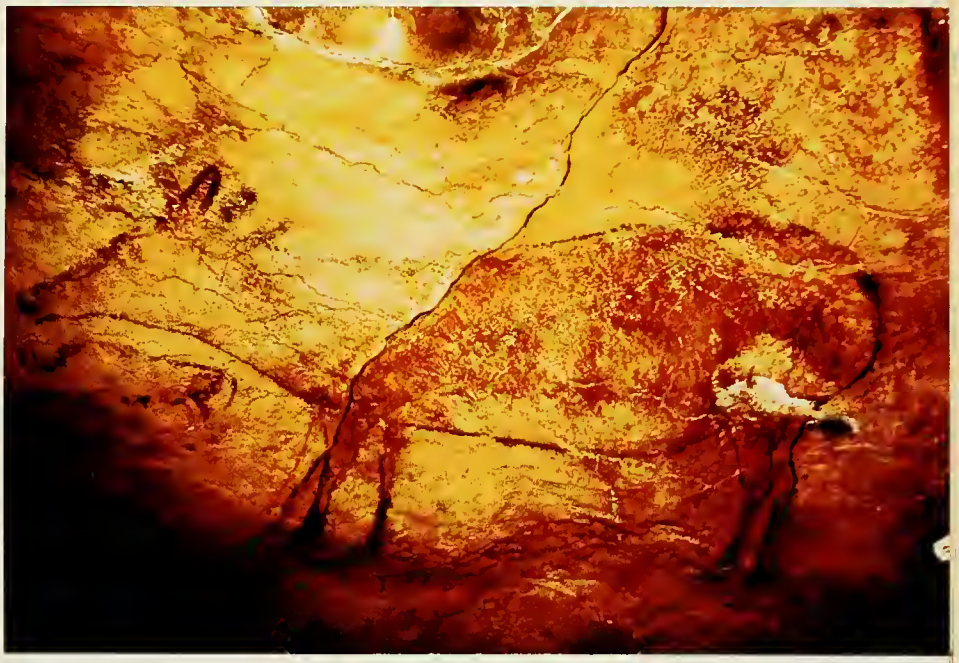
Eskimo artists concern themselves with both natural appearances and inner realities. As hunters they observe nature carefully, and as artists they match their carvings with nature. Some carvings are so accurate, so detailed, that one can tell, say, a common loon from a red-throated loon.

But when these artists depict



The cave paintings of prehistoric Europe, dating from 35,000 to 10,000 B.C., are examples of secret art. Probably painted by torchlight, most are situated deep in caves and presumably had ritual significance. The horse, left, is in a cave at Lascaux, France; the bison, below, is on the ceiling of a cave at Altamira, Spain.

The Bettmann Archive, Inc.



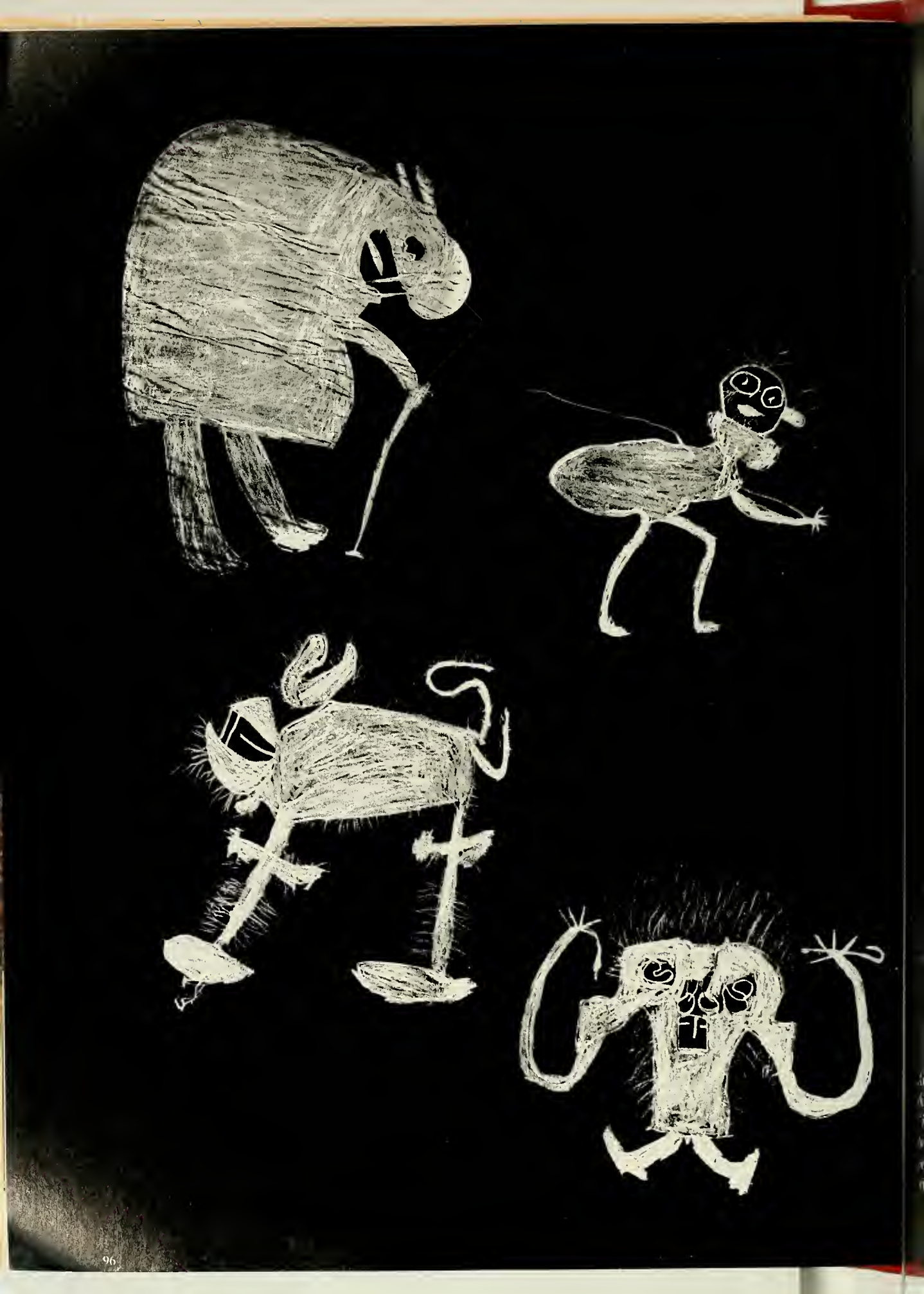
inner reality, art becomes making, not matching, and images become surrealistic. As one Netsilik woman said, "We believe that people can live a life apart from real life."

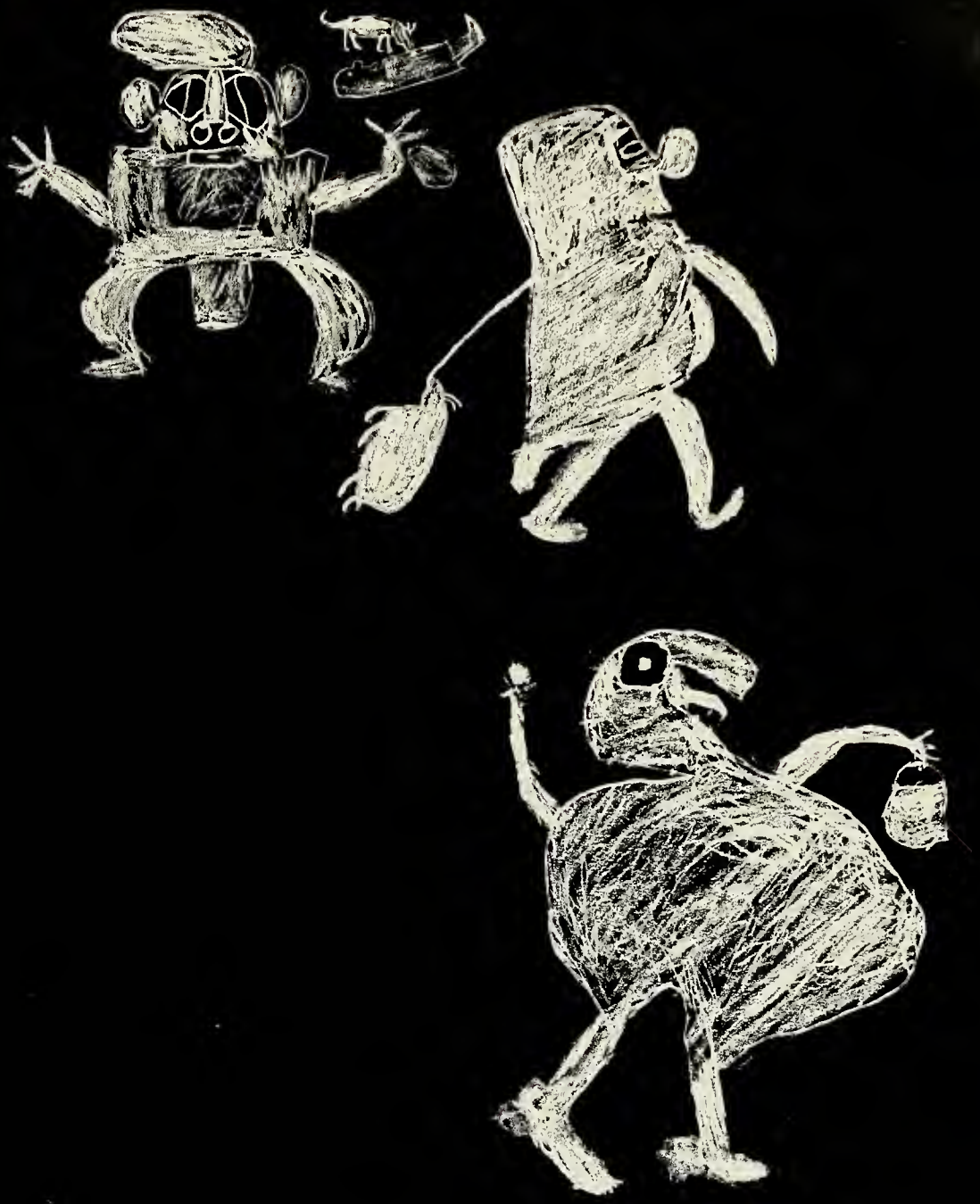
The Danish ethnographer Knud Rasmussen tells of asking Anarqaq, an Eskimo shaman, to draw spirit visions: "He would sit for hours with closed eyes, solely intent on getting the vision fixed in his mind, and only when this was done would he attempt to put it into form. Sometimes the recollection of the event affected him to such a degree that he trembled all over, and had to give up the attempt."

Anarqaq consented to make these drawings on the condition that Rasmussen take them to his own country and not show them to Anarqaq's people.

Ritual words can be more important than visions. Sometimes they are a source of artistic inspiration or the basis for skill and status. And sometimes they are the power behind certain ceremonies, incantations, rites. The efficacy of ritual paraphernalia and protective designs often depends on them. Like visions and silent music, ritual words are privately owned by individuals who keep them to themselves.

How do you paint a song? How





Anarqaq, an Eskimo shaman, drew these images of spirits. The "in-visible" pictures appeared to him while he sat for long periods in silent concentration with his eyes closed.

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do you carve a word? One way is to use an acoustic model: make the eye subservient to the ear by patterning space acoustically. An essential feature of sound is that it fills space. We say, "The night shall be filled with music," just as the air is filled with fragrance. The concert-goer closes his eyes.

Auditory space has no favored focus. It is a sphere without fixed boundaries, space made by the thing itself, not space containing the thing. It is dynamic, always in flux, creating its own dimensions moment by moment.

Alaskan Eskimo mask makers were inspired by songs heard in dreams. Each design, obedient to an inner impulse, creates its own dimensions, asserts its own identity, unhampered by external restraints. Used once, each mask was then burned.

Japanese and Tibetan Buddhism are full of esoteric paintings and images not supposed to be seen. Certain Buddhist mandala must be destroyed almost as soon as they are completed.

In the Japanese secular art of *bonseki,* the artist is required to destroy his sand paintings after about two weeks. Navaho sand paintings qualify as "sand mandalas" with the same requirements. In fact, sand paintings in many parts of the world are generally erased as a final step in their production. Chants associated with them are kept secret.

Rituals and sacred dances are impermanent art forms, and often the articles produced for them are destroyed at the close of the performances. This custom is so widespread as to suggest great antiquity.

Among the Eskimo, carvings are rarely saved. When spring comes and igloos melt, old habitation sites are littered with waste, including beautifully designed tools and tiny carvings, not deliberately thrown away, but with even greater indifference, just lost.

To the Eskimo, a carving, like a song, isn't a thing. When you feel a song within you, you sing it; when you sense a form emerging from the ivory, you release it. As the carver holds the unworked ivory lightly in his hand, turning it this way and that, he whispers, "Who are you? Who hides there?" And then: "Ah, Seal!" He rarely sets out to carve, say, a seal, but picks up the ivory, examines it to find its hidden form, and if that is not immediately apparent, carves aimlessly until he sees it, humming or chanting as he works. Then he brings the form out; the hidden seal emerges. It was always there. He didn't create it, he released it; he helped it step forth.

Eskimo are more interested in the creative activity than in the product of that activity. Art to them is a transitory act, a relationship.

Hidden art takes many forms: an insignia on the inner side of an Elizabethan finger ring; entire Indonesian temples concealed beneath stone structures; paintings on the inside of a mummy case, facing the deceased.

I once saw a gold brooch whose form was abstract, until you blew on it, at which point its spinning parts formed the letters KKK, for Ku Klux Klan.

Small cabins on the banks of the Rhine belong to families whose fishing rights date from medieval times. During *Fastnacht,* a three-day winter festival, cabins are left unguarded. An unidentified artist selects one and covers its inner walls with pornography. When the owner returns, he may simply lock the door or he may invite friends. Either way, tradition requires that the paintings remain for one year; then they are eradicated. Such paintings generate wide speculation. Rumors abound. Old tales are revived. Yet only a few people actually see anything.

A tribe has been defined as a community where everyone shares all information simultaneously. But surely not all information? Even the smallest band of tribesmen keeps secrets and enjoys mysteries, and art is a favorite hiding place for both. Tribal art is filled with puzzle-pictures and visual puns and cryptic messages in cartoon shorthand. No stranger deciphers even the first layer of these many ambiguities.

Perhaps we should redefine a tribe as a group whose shared knowledge permits communication through secrecy. We, who have lost this ability, create instead the ultimate in accessibility as a substitute for the network of tradition.

We love to *solve* mysteries. Our children, when visiting their grandmother, head first for the attic, to open trunks. I was fascinated to learn that a safe deposit in Basel can be opened only by its owner, even if it lies dormant for a thousand years. Fascinated but skeptical: could any Westerner, even a Swiss, resist a mystery for a thousand years?

Recently a museum collection of African fetishes, each sealed in leather shrouds, proved too tempting; the curator X-rayed them, thus satisfying his curiosity while preserving their bindings.

If there is an Indian mound in the neighborhood, we open it. I doubt that a single known mound in North America has escaped violation. Nearly forty years ago, as an archeologist, I asked a landowner for permission to open a burial mound. He refused on the grounds that he respected the mystery. I was disappointed but I never forgot, or condemned, his decision.

When American Indians burn their sacred treasures, rather than sell them to us, we are disappointed and puzzled, and that puzzlement derives partly from respect.

Perhaps the real message of tribal art is not its form or its beauty, but its reminder of the gift of privacy.

I accept that there are mysteries best left unsolved—that some answers must forever elude outsiders. I was once very close to several Eskimo friends but I gave up hope we could ever come to know each other completely. If I had come to know them completely, I would have become an Eskimo; I would have lost my own identity, and this I did not choose to do.

"We wed ourselves to the mystery," not to conquer it or be conquered by it, but to greet it. □

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A Matter of Taste

Slippery Characters

A shocking congeries of facts about current morays

Eels get a very bad press. Part of the stigma stems from pure ignorance. In the Great Lakes region, eels have been tarred with the same brush as their look-alikes, the lampreys. Lampreys are not eels at all, but eellike fish, which until recently menaced the survival of more conventional table fish such as Lake Michigan whitefish. Leaving aside that the dread lamprey itself has been prized as food for eons in Bordeaux (and that these ugly predators could have been eaten by Michiganders instead of merely killed for bounty by the environmentalists who recently succeeded in decimating them), it is particularly unfair that the eminently palatable true eels of the order Anguilliformes should have been confused with lampreys and made to bear the burden of yet another prejudice, that eels are electric. True eels are not electric (electric "eels" are related to carp), and they are notably delicious.

This is not some eccentric quirk of taste that I developed during my misspent life. Almost the entire civilized world votes with me on the eel question. Let us begin with the ancient Greeks, who so doted on the eels of Lake Copais in Boeotia that Aristophanes was able to build an entire comedy around the predilection. *The Acharnians* involves a separate peace struck by private citizens whose craving for Copaic eels and other exotic delicacies was so strong that they declared a personal armistice during the Peloponnesian War.

In Germany, whenever you turn around, someone offers you smoked eel, as if it were his virgin daughter and you were the luckiest man in the world to be getting such a treat. Spanish groceries in New York carry tins of baby eels, officially known as elvers. In England, one of the few surviving British dishes of universally high quality is jellied eels. Any seafood restaurant has this remarkable, refined dish. The Japanese and Chinese devour eels with abandon. And knowledgeable New Yorkers, fleeing the city for a weekend in the Hamptons, will stop at one of the roadside stands to buy locally speared and smoked eel.

Then, ensconced beside the dunes, they can squeeze a little lemon on that tender and unfishy flesh, all white around the central bone. The meat forks away easily, and downed with a shot of cold vodka, eel is as good as food gets. And there are millions of eels swarming and writhing in our local waters, waiting to slither into our nets. So why do we spurn *Anguilla rostrata*? Because we have allowed irrelevant characteristics of eel anatomy and physiology to repel us.

Eels look like big worms. They evolved without the bony skeletons of the less primitive, more conventional teleost fish. They breath with gills and have backbones like other fish, but eels are long and sinuous. They are apparently scaleless, have no pelvic fins, and lack dorsal spines. Their tails are pointed, not forked, and they slink through the water (this undulating movement gave rise to the 1920s expression: "She's the eel's hips").

Also, eels are slimy. This mucous

by Raymond Sokolov

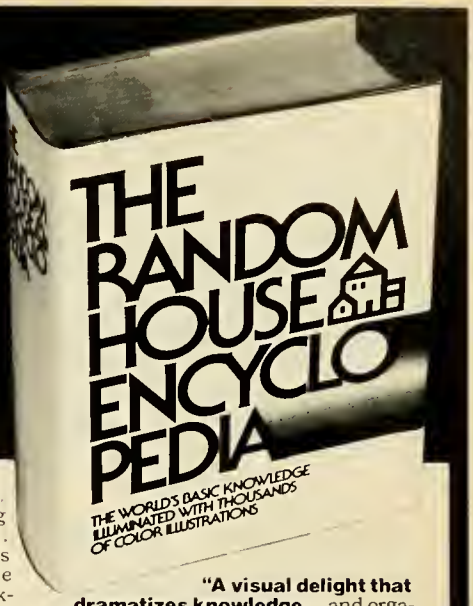
exudation is extremely useful to eels because it retains moisture on their skin surface, allowing them to respirate through the skin. That means that eels can survive on land for periods as long as two days. The Irish ichthyologist Christopher Moriarty, in his *Eels: A Natural and Unnatural History*, says:

I usually place my captives at once in anaesthetised water in the bottom of a large dustbin. Otherwise they have a disheartening way of leaping out of a small boat or hiding beneath the floorboards. Freshwater eels on migration will leave the water if they meet a barrier and can make long journeys through wet grass. Little eels wriggle through damp moss in preference to trying to swim up a waterfall and there are records of eels crawling out on land to forage.

Moriarty also points out that the ability of eels to survive without much oxygen makes them powerfully resistant to water pollution. Moriarty does not say so, but it is obvious that this faculty makes eels good bets to survive as food fish in our coastal waters and industrially polluted rivers long after more picturesque species hit bottom.

Perhaps the one truly alarming aspect of the eel is its still mysterious life cycle. The eels most familiar to Americans and Europeans spawn in the Sargasso Sea, that vast Atlantic seaweed wasteland better known as the Bermuda Triangle. The actual mating procedure is not well understood, and the instinctual drive that sends the European common eel (*Anguilla anguilla*) on a migratory circuit of thousands of miles through open ocean is a largely unexplained phe-

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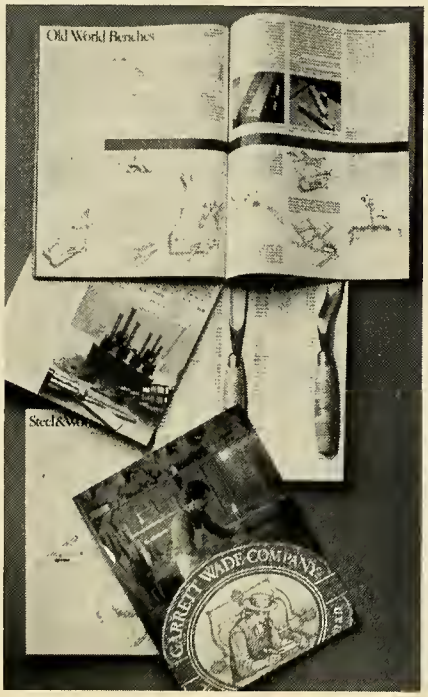
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nomenon. Warm water, which is abundant in the southern Atlantic, seems to be at the heart of the enigma. Depth also counts, but no one knows why.

Eel reproduction has excited much fantastic commentary. Aristotle asserted that eels were sexless and arose out of mud through spontaneous generation. One reason for this apparently bizarre notion is the eel's minute ovary, so tiny that it is barely visible to the naked eye. Even today, when the basic facts of eel sexual anatomy are known, sexing little, transparent elvers is a chancy business. Older, bigger eels are an easier bet, but maturation in eels is not a straightforward matter. Population density seems to affect the statistical balance between male and female fish. Some fish do not mature at all if water conditions are unfavorable. Perhaps the only, easily documented fact in the eel life cycle is the animal's age. Like trees, the eel's otoliths—balancing organs at the base of its skull—develop annual rings observable by microscope. The otoliths prove that eels can age, with sinuous grace, to a silvery eighty-five.

For the fisherman or cook, these anguillan arcana are not of prime importance. When eels swarm, men can net or spear them with relative ease. Then the trouble begins. Dispatching eels quickly is necessary but not fun. Some people chill them to death, but the classic method is to cover them with salt; the resultant release of slime is followed by suffocation. After the slime is scraped off, eels can be smoked with the skin on. For other cooking preparations, skinning is a bothersome essential. In one method, the head is nailed to a board, a cut is made around the neck, and the skin is pulled off toward the tail in one tubular piece. It is also possible to cut the head away, except for a point of attachment to the skin. Then, holding the exposed flesh at the neck with one hand and pulling down on the head with the other, the head and skin can be completely detached.

Given a skinned, cleaned eel, cooking the fish is a simple affair. Just cut an eel into inch-long segments, dredge in flour, and fry until brown. There are also various classic recipes; unfortunately, the greatest is impractical for most people. Too many herbs, unusual in American gardens, must go into the famous green sauce for the Belgian *anguilles au vert*. But if you have a source for fresh chervil, sorrel, and tarragon, you should not fail to try the version of the dish in Nika Hazelton's *The Belgian Cookbook*. The other outstanding culinary treatment of eel is a French stew called matelote (see recipe), which comes in several regional variations, all of which involve a wine-based broth. Around the Seine, carp and other river fish are added. Red wine is more usual than white, which seems to be used only in Anjou. In Provence, the *catigau* is a wineless stew of eel, leeks, and tomato.

In Italy, the eels of Comacchio on the Adriatic are marinated and spit roasted, then served with *mostarda*, fruits preserved in mustard. Italians also stew eel in vegetable or white wine broth, with characteristic Italian seasonings. Indeed, most cultures cook eel as they would other delicate, white fish. Moroccans bake large pieces of conger with such typically Moroccan flavorings as orange-flower water, sugar, raisins, and saffron. New Englanders layer eel, potatoes, and onions in a casserole. In Chile, where conger is the most popular of all fish, it is baked with tomato, limas, potatoes, and corn.

For a completely original approach to eel, one goes to England, where they poach pieces of eel in seasoned broth and then reduce the broth until it gels like an aspic when chilled. Sometimes the cook has to add gelatin to the reduction, but natural eel broth is usually gelatinous enough, and very tasty.

Finally, there is the question of eel connoisseurship. Of the dozens of edible species, which eels are the best? Is it environmentally noxious to consume elvers? Are long eels more delicious and tender than short ones? Some authorities prefer long eels; others advise us to opt for those of medium length. As with all debates about food quality, these controversies cannot be easily resolved in definite terms and depend to a large extent on individual taste. Local supply will, practically speaking, solve most of these problems for you. Only a few species are usually available. As for length, it is hard to know what people mean when they propagandize in vague language for "long" eels. After all,

the range is very great. Eels can commonly attain more than a yard from nose to tail. And there are reports of veritable sea serpents. The biggest, almost certainly factitious, was Pliny's monster from the Ganges, a 200-foot eel. It is perhaps pedantic to wonder what such a behemoth could have tasted like, but practical eel gastronomy is not a farfetched subject. Eels are a rare instance of a food source of the highest order that has never been sensibly exploited. There should, I mean, be an eel in your future.

Eel Matelote with Raisins

- 8 tablespoons butter
- 4 white onions
- 2 carrots, quartered
- 2 cloves garlic, peeled
- ⅓ cup flour
- 1 cup water
- 3 cups dry red wine
- 2 tablespoons cognac
- Bouquet garni (½ stalk celery, 2 sprigs parsley, 2 sprigs fresh thyme, or ½ teaspoon dried, and 1 bay leaf)
- 1 whole clove
- Salt
- Pepper
- 3–4 pounds live eels, heads removed, cleaned, skinned, and cut into 2-inch lengths (about 1½–2 pounds pan-ready fish, if you are ordering from a fish market)
- ½ pound mushrooms
- 2 tablespoons lemon juice
- Boiling water
- ½ cup golden raisins
- 6 small triangles thin white bread, crusts removed

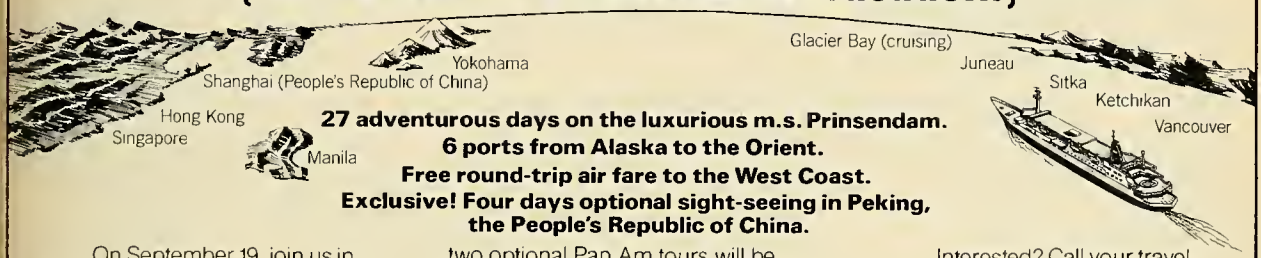
1. Melt 3 tablespoons of the butter in a heavy saucepan. Add the onions, carrots, garlic, and flour, and cook, stirring, over medium-low heat until the vegetables are coated with a deep golden layer of flour. This will take about 10 minutes. Do not allow flour to burn or it will be bitter.
2. Stir in the water, the wine, and the cognac to make a smooth sauce. Add the bouquet garni, the clove, salt, and pepper. Bring to a boil, cover and simmer 45 minutes. Stir occasionally.
3. Melt 3 tablespoons of butter in a skillet. Brown the eel pieces quickly on all sides. Remove the fish and keep warm. Reserve 6 whole mushrooms for garnish; chop or slice remaining mushrooms. Add chopped and whole mushrooms to butter remaining in the skillet. Add lemon juice. Sauté mushrooms five minutes.
4. Pour boiling water over raisins. Let stand 3 minutes. Drain.
5. Strain sauce into a clean saucepan. Add the eel, cover the pan, and cook gently 10 to 30 minutes, until the fish is opaque all the way through and flakes easily. The exact time will depend on the diameter of the eel pieces.
6. Fry the bread triangles in the remaining butter. Drain on paper towels.
7. Add the chopped mushrooms and raisins to strained sauce. Arrange the eel pieces on a platter, spoon over some of the sauce and serve the rest separately. Garnish the platter with the whole mushrooms and bread triangles.

Yield: 4 servings

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.

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The Mythic Indian

THE WHITE MAN'S INDIAN: IMAGES OF THE AMERICAN INDIAN FROM COLUMBUS TO THE PRESENT, by Robert F. Berkhofer, Jr. *Alfred A. Knopf, $15.00; 261 pp., illus.*

In 1646, one of his "praying Indians" posed a question to the Massachusetts missionary John Eliot: "Why do you call us Indians?" The answer, of course, is deceptively simple: Columbus had erred and believed his landfall was somewhere in the Spice Islands of the Indies (a vast and vague geographical area that stretched from Japan to India). Even after subsequent explorations corrected Columbus's error in geography, Europeans continued to refer to the native inhabitants of the New World as *Indios* (Spanish), *Indiens* (French), *Indianer* (German), and our English *Indians*.

But the seemingly ingenuous question requires a much more profound reply, one that does, in fact, represent the major thesis of Berkhofer's book: Europeans, and later White Americans, maintained the erroneous name because Indians are an artificial construct of Euro-American attitudes, beliefs, and prejudices. Berkhofer makes an excellent case for the semantic distinction between "Indians" and "Native Americans"—the former as stereotype; the latter as the living, breathing human beings with diverse cultures who were the only inhabitants of the hemisphere prior to 1492. The distinction might appear self-evident to us nowadays, but for five centuries it almost never occurred to those Euro-Americans who perceived, observed, evaluated, and even judged the natives with whom they came in contact.

A basic paradox of this construct is that White American attitudes have had little relationship to the cultures the particular stereotyped Indians came from. Apache warrior and Cherokee Christian were treated with the same blind brutality. In short, the artificial construct of *the* Indian was the constant in the Americas. The variable was the White American attitude, which changed from time to time and from place to place; the attitude had almost nothing to do with how well or how badly Reds responded to Whites. Enemies of the Whites were deprived of their lands, their families killed, their cultures destroyed —just as were those regarded as friends. So the real question that might have been asked of Eliot (and of all the generations since) is: Why do you think of us as you do?

That Euro-Americans even considered the artificial construct of *the* Indian as existing in the first place is grotesque. Native Americans never formed a single culture nor did they use any single term to refer to themselves. At least two thousand different cultures flourished in the Americas at the time of Columbus. They were distinguished by a multiplicity of customs, a rich variety of values and beliefs, and numerous unrelated languages, each with many dialects. By classifying these many peoples as "Indians," Whites grossly oversimplified the social, cultural, and linguistic differences among those so labeled. And so we got the bewildering array of contrasts: "Noble Savage" and "Bloodthirsty Red Man"; the stolid yet emotional Indian who could be both cunning and childlike; both the "innate" conservationist and the "natural" blight on the wilderness. The sad truth is that for nearly five centuries one stereotype or another of the Indian has been more real to Whites than have the actual Native Ameri-

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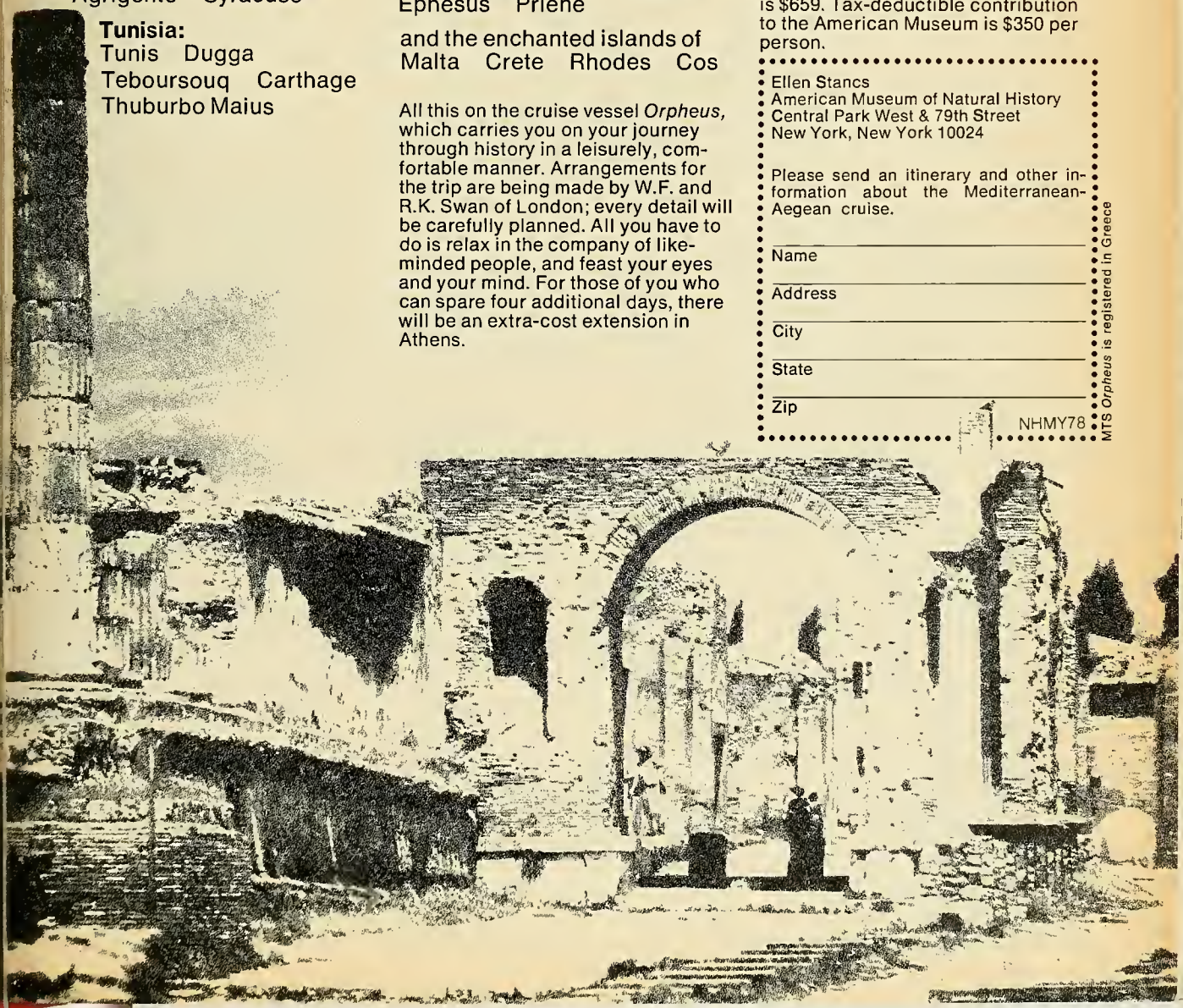
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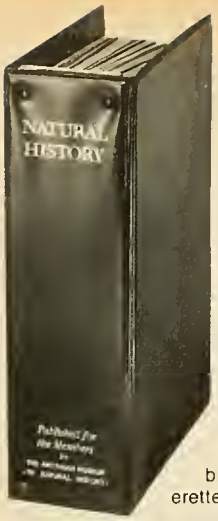
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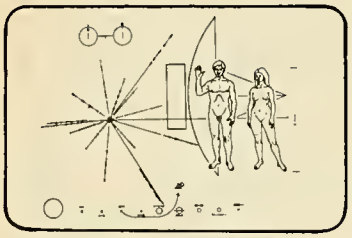
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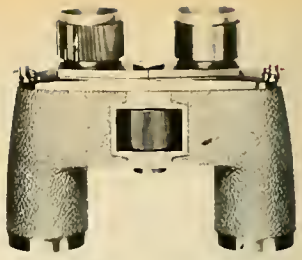
cans in all their wondrous cultural diversity.

After nailing down these points—and doing so with all the intellectual rigor of a legal brief—Berkhofer devotes the remaining 165 pages of his book to documenting the persistence and the perpetuation of the artificial construct: in the attitudes of divines and anthropologists, in literature and art and popular culture (film included), and finally in governmental policies. He discusses, at a breathless pace, the folk attitudes that preadapted European explorers and settlers to accept the stereotype, the "scientific" imprimatur given these folk beliefs by the distinguished taxonomist Linnaeus, the distortion of Darwinian evolution in its application to native cultures, and the emergence of different images of Native Americans in the writings of churchmen, hacks, and even classic novelists.

The final section of the book, and the longest, summarizes the political relations between Whites and Reds: the extermination through famine, disease, and dislocation of countless millions of Native Americans (which, amazingly, the author regards as possibly a "myth"), the removal of all eastern Indians to west of the Mississippi, the growth of the reservation idea—everything, down to the recent Second Battle of Wounded Knee and the current militancy of the American Indian Movement. This partial catalog of topics could not possibly capture the author's whirlwind of ideas, speculations, and truths (alas, occasionally half-truths) that gives this small book an extremely high specific gravity. In many ways it is an admirable exposition—written in biting, ironic, and aphoristic prose—to sustain an indisputably valid thesis.

But what a penalty the author pays for his brevity! For example, he mentions what sociological and psychological jargon refers to as the "negative reference group." He wisely states that when the Puritans projected "their own sins upon people they called savages, then the extermination of the Indian became a cleansing of those sins from their own midst as well as the destruction of a feared enemy." A telling point, which is then dropped almost never to reappear.

The reader is left largely ignorant of the distortions caused by Franz



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Boas, who presided over American anthropology during its formative half-century, and his students who bequeathed to us inept field methods, naive observations, and facile conclusions. How could Berkhofer possibly gloss over Herman Melville's "Metaphysics of Indian-hating" in *The Confidence-Man,* something certainly crucial to his thesis? Or ignore the immense influence of the editor and poet William Cullen Bryant whose much-read "The Prairies" (1832) cheerfully described the bleak western lands to which the eastern Indians were removed as "a little Venice"? Why does he largely ignore Robert Montgomery Bird's *Nick of the Woods,* which went through thirty printings in several decades and molded the Indiophobic attitudes of Poe, Twain, Theodore Roosevelt, and in fact three generations of White Americans? Washington Irving's *Sketchbook* receives mention in passing—but where is the same Irving who pictured Indians as thieving, lazy rascals, wily marauders without mercy, in *Astoria,* a book that John Jacob Astor virtually dictated to him? And as Irving later confessed, paid "liberally for the time and trouble" to justify Astor's rape of the western fur lands and of the Native American cultures that occupied them.

These are a few, only a very few, of the crucial omissions. Sins of commission—that is, actual distortions—although fortunately few, can also be found throughout the book. For example, on page 96 Berkhofer repeats the substance of an extraordinary statement made ten pages earlier: "As White settlement proceeded across the Missouri River and the Indian Wars receded ever more westward, the Indian lost his place as an important subject in what we might call elite or formal art and literature." Berkhofer thus dismisses from our intellectual history such classic authors and their works as Twain's *Pudd'nhead Wilson* and *Tom Sawyer* (complete with the stereotype of "Injun Joe"), Hart Crane's major work *The Bridge,* the short stories and *The Torrents of Spring* of Hemingway, D. H. Lawrence's *The Plumed Serpent,* William Faulkner's *The Bear* (considered by some his most perfect work), La Farge's *Laughing Boy,* Conrad Richter's *Light in the Forest,* and Robert Lowell's *Old*



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George Catlin's painting depicts an Assiniboin chief going to and returning from Washington.

Glory—to list just a few. And certainly the author's view of contemporary attitudes about Native Americans must be askew when he regards modern novels with Indian themes—such as Thomas Berger's *Little Big Man*, Ken Kesey's *One Flew Over the Cuckoo's Nest*, and even *House Made of Dawn* by Native American Scott Momaday—as merely "countercultural."

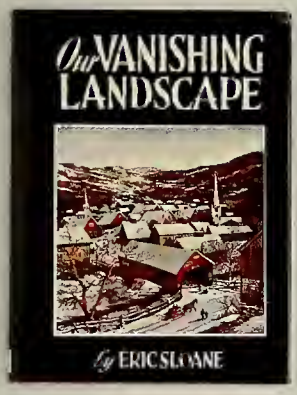
In summary, this book reads like a terse outline for a much grander work that the author assuredly is qualified to write. Indeed, that is pretty much what it is: the book consists mainly of ideas the author has already summarized in chapters for the Smithsonian Institution's *Handbook of North American Indians*, now in preparation. For those who cannot wait for the entire volume in which these essays will appear, the present slim book under consideration represents a unique purchase, for nothing exactly like it exists between one set of covers. But for approximately the same dollar investment, other readers might want to put together their own paperback library of books that cover much the same ground in considerably greater detail and variety: *Savagism and Civilization*, by Roy Harvey Pearce; *The Return of the Vanishing American*, by Leslie Fiedler; both *The Indian in America* and *The Indian and the White Man*, by Wilcomb Washburn; and *The New Indians*, by Stan Steiner.

Peter Farb's Man's Rise to Civilization: The Cultural Ascent of the Indians of North America *has just been published in a completely revised second edition.*

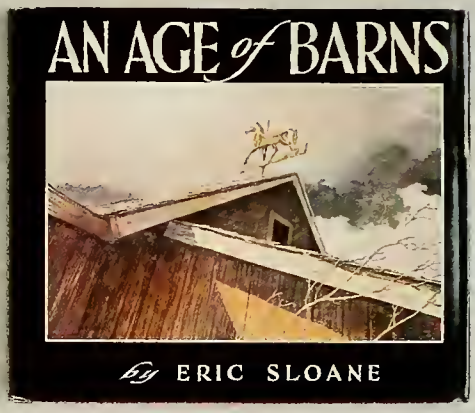
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Additional Reading

The Tuntong (p. 36)

Although there are many herpetology books, only a few include the tuntong, *Batagur baska*. Among them are Peter Pritchard's *Turtles of the World* (Jersey City: T. F. H. Publications, Inc., 1966), an illustrated natural history with a good bibliography; *The World of Amphibians and Reptiles*, by Robert Mertens (New York: McGraw-Hill Book Co., Inc., 1960), which takes an ecological and ethological approach; and a summary of F. D. Maxwell's findings on *Batagur* in Karl P. Schmidt and Robert F. Inger's *Living Reptiles of the World*, published in 1975 by Doubleday and Company, Inc. "With a Casting Net," a short article about the turtle egg-collecting parties of Malaysian royalty at the turn of the century, is reprinted in *Stories and Sketches by Sir Frank Swettenham*, selected by William R. Roff (Kuala Lumpur: Oxford University Press, 1967). A short article, "River Terrapin," by Mohd. Khan bin Momin Khan, on the West Malaysian Game Department's plans for the conservation of *Batagur* appeared in the July 1977 issue of *Nature Malaysiana*.

Small Ungulates (p. 44)

Much of what is known about the behavior and ecology of small ungulates is contained in *The Behavior of Ungulates and Its Relation to Management*, volumes 1 and 2, edited by V. Geist and F. Walther, and published in 1974 by the International Union for Conservation of Nature and Natural Resources, Morges, Switzerland. Paper no. 8, by Richard D. Estes, and paper no. 10, by V. Geist, both in volume 1, are particularly important. P. J. Jarman's "The Social Organization of Antelope in Relation to Their Ecology" (*Behaviour*, 1974, pp. 215–67) and K. L. Tinley's "Dikdik *Madoqua kirki* in South West Africa: Notes on Distribution, Ecology, and Behavior," (*Madoqua*, 1969, pp. 1–33) are technical but have good bibliographies. *Portraits in the Wild*, by Cynthia Moss (Boston: Houghton Mifflin Company, 1975), is a readable review of the material on the dik-dik. Rennie Bere's *Antelopes* (New York: Arco Publishing Co., Inc., 1971) is a beautifully illustrated work. Two papers that discuss the water metabolism and thermal biology of African and Asian small ungulates are "The Water Metabolism of a Small East African Antelope: The Dikdik," by G. M. O. Maloiy (*Proceedings of the Royal Society of London*, Series B., vol. 184, pp. 167–78), and "Temperature Regulation in the Smallest Ungulate, the Lesser Mouse Deer (*Tragulus Javanicus*)," by G. Causey Whittow et al. (*Comparative Biochemistry and Physiology*, Series A, vol. 56A, pp. 23–26).

Capital Punishment (p. 50)

Capital Punishment: The Inevitability of Caprice and Mistake, by Charles L. Black, Jr., traces the decision-making process behind the application of the death penalty and argues that the system is without standardization. This paperback was published in 1974 by W. W. Norton and Company, Inc., New York. *Deathwork*, by James McLendon (Philadelphia: J. B. Lippincott Company, 1977), although a novel, is an accurate, hour-by-hour account of the last three days of a man on death row. A serious study, with extensive notes, facts, and cases covering the law, capital punishment as a deterrent, and the death penalty in America, is Hugo A. Bedau's *The Courts, the Constitution, and Capital Punishment* (Lexington: Lexington Books,



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1977). Although out of print, *Capital Punishment*, edited by Grant S. McClellan, is a good collection of articles that appeared in popular news magazines such as *Time* and *Life* in the early 1960s. Published in 1961 by the H. W. Wilson Company, New York, the book has a good bibliography. *Voices Against Death: American Opposition to Capital Punishment, 1787–1975*, edited by Philip E. Mackey (New York: Burt Franklin and Company, Inc., 1977), includes 26 selections from the writings of the most famous opponents of the death penalty. The book includes a bibliography. BBC TV's *Death Row*, a 49-minute, 16-mm color film distributed by Time-Life Films, presents interviews with three convicted murderers who have been awaiting execution for years in the Huntsville State Prison in Texas. Although the film is no longer distributed, it is still available in some libraries.

George Edwards (p. 72)

The first four volumes of George Edwards's work (published in London between 1743 and 1751) were printed at the College of Physicians in Warwick-Lane under the title *A Natural History of Uncommon Birds*. The last three volumes (1758–1764) were entitled *Gleanings of Natural History*. Beautifully illustrated, these rare books are worth seeking out. Elsa Allen's "The History of American Ornithology Before Audubon" (*Transactions of the American Philosophical Society*, New Series, vol. 41, 1951) studies ornithology and ornithologists from Aristotle to Audubon and has an extensive bibliography. "George Edwards, F.R.S. (1694–1773): An Eighteenth-century Naturalist," by T. E. James, volume 27 of *Science Progress* (1933), is a biographical article that includes some letters to C. Linnaeus. In volume 37 of the *Bulletin of the Field Museum of Natural History* (1966), W. P. Fawcett reproduces some of Edwards's engravings and letters from the collection of the Chicago Field Museum. *How Prints Look: Photographs with a Commentary*, by William M. Ivins, Jr. (Boston: Beacon Press, 1958), includes a sec-



The Monax, Or Marmotte, Of America (woodchuck), by George Edwards

tion on copper plates and intaglio.

Silent Music (p. 90)

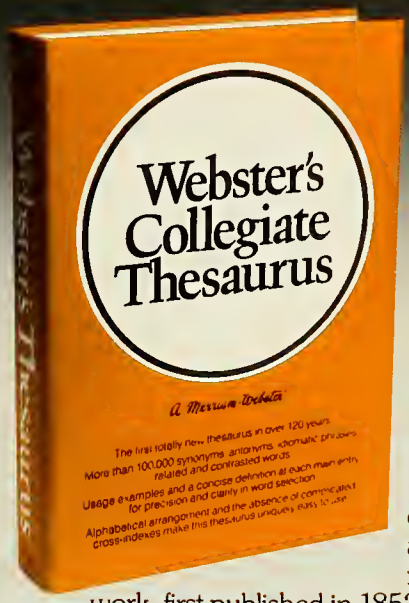
Princeton University Press has just published three volumes on the work of Ananda K. Coomaraswamy, the great Indian metaphysician and art historian. Volume 2, *Coomaraswamy: Selected Papers of Metaphysics*, edited by Roger Lipsey, has a chapter on the Vedic doctrine of "Silence."

The theme of Edmund Carpenter's *Eskimo Realities* (New York: Holt, Rinehart and Winston, Inc., 1973) is that art is integrally tied to Eskimo life and survival. *Silence* (Middletown: Wesleyan University Press, 1961) is a collection of lectures and essays by John Cage. The work is a rhythmic composition of disconnected, unconventional thoughts using, and concerning the uses of, silence and noise, nothing and something, indeterminacy and change in art, music, and poetry. *The Eternal Present*, by Siegfried Giedion, which features cave paintings, was published in 1964 by Princeton University Press.

Katharine D'Agosta



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glad *adj* **1** characterized by or expressing the mood of one who is pleased or delighted <he was *glad* to be on vacation>
syn happy, joyful, joyous, lighthearted
rel delighted, gratified, pleased, rejoiced, tickled; blithe, exhilarated, jocund, jolly, jovial, merry; gleeful, hilarious, mirthful
idiom filled with (*or* full of) delight
con blue, dejected, depressed, downcast, melancholy; despondent, dispirited, heavyhearted, sadhearted, unhappy; forlorn, joyless, sorrowful, woeful
ant sad
2 full of brightness and cheerfulness <a *glad* spring morning>
syn bright, cheerful, cheery, radiant
rel beaming, sparkling; beautiful; genial, pleasant
con dark, dim, dull, gloomy, somber
gladden *vb* ***syn*** PLEASE 2, arride, delect

At the Museum

When a New York artist sculptured a *Stegosaurus* from snow on the Museum's lawn last March, he didn't realize that the 26-foot mammoth would be an appropriate herald for the Museum's spring show, opening May 24. **Ice Age Art** will be the first comprehensive survey of the earliest and longest (35,000 to 10,000 B.C.) movement in art history—the paintings, engravings, and sculpture of *Stegosaurus'* cave-dwelling human contemporaries before they settled down to farming and village life.

The show's organizer, Alexander Marshack of Harvard's Peabody Museum, and the Museum's Exhibition and Graphics Department have assembled photographs of paintings and engravings from more than one hundred paleolithic caves in France, Spain, and Italy, including some of the best-known cave paintings from Lascaux in southwest France. Photographs are now most art lovers' only means of appreciating Lascaux, since the caves have been sealed to protect the paintings from destructive bacteria.

According to Marshack, "Everyone knows about cave paintings, but few people realize that there are all kinds of other evidence of the sophistication of paleolithic society." In order to draw a three-dimensional portrait of Ice Age people, Marshack has collected photographs of their physical environment—the steep, narrow river valleys of southwest France where Cro-Magnon man's remains were discovered. From American, French, Russian, and Czechoslovakian museums, Marshack has borrowed a few rare original pieces, as well as many casts of prehistoric jewelry, ceremonial objects, musical instruments—including bone flutes with full octaves—and statuettes of plump, faceless fertility goddesses, among them a cast of the Venus of Willendorf, the oldest known sculpture of a human figure, dated to 25,000 B.C.

To make these casts look indistinguishable from their ivory, bone, horn, or limestone originals, two young designers, Dennis O'Brien and Liza Donnelly, set to work in the Exhibition Department with molds, wax, sandpaper, picks, and oil washes. Since many pieces have been engraved over and over, perhaps during communal rites, O'Brien worked from Marshack's microphotographs of the originals.

Marshack began examining Ice Age art under microscopes and ultraviolet and infrared light after he noticed that some markings on a paleolithic bone tool handle appeared to be, not decorative, but calendric—records of phases of the moon. Marshack has established that Ice Age people could measure time and therefore were aware of the cycles of plants, animals, and seasons. They were also intelligent, observant natural historians: cave paintings document more than fifty animal species, frequently noting age, sex, and seasonal behavior. Other paintings depict fantastic beasts, ancestors of populations in medieval bestiaries or mammals now extinct in Europe—musk ox, ibex, chamois, and the woolly mammoth that inspired the snow beast on the Museum lawn. For the show, Marshack has found a mammoth's skin, revealing that the animal was not snow white but rust red.

Prehistoric people also drew each other. In portraits found mostly in France at La Marche, the subjects are far from brutish looking; they wear shirts of ivory beads, not just animal skins. Leafing through a portfolio depicting men with retroussé noses, beards, mustaches, and caps; women with headbands, elaborately dressed hair, and jewelry; old people praying and young people dancing, Marshack noted, "These people looked like us, acted like us, used symbols as we do. Their society was probably as complex as ours."

While we can place paleolithic people among appropriate flora, fauna, and geography—and even envision their faces—we cannot decipher Ice Age myths, symbols, and rituals. We still do not understand the purpose or meaning of cave art. We only know that it does not resemble the art of any primitive culture. Marshack feels that his studies and the Museum's survey of Ice Age art simply teach us how to ask better questions about prehistory.

On Mother's Day, May 14, at 3:00 P.M., **Margaret Mead** will speak on parenthood in the Museum auditorium. Curator emeritus of ethnology, Mead, herself a grandmother, has devoted much of her long career to studies of parents and children. In her autobiography, *Blackberry Winter*, she writes that she never assumed that her strong commitment to scholarship negated her equally strong desire for motherhood. Since many women would like to emulate Mead's successful meshing of work and child rearing, her thoughts on parenthood are welcome. Admission for Participating, Donor, and Life Members is two tickets for $5.50, and $5.50 per ticket for Associate Members and the public. For information regarding advance ticket sales call (212) 873-1327.

Other Events

Wednesday, May 3: "Wolves and Their Prey on Isle Royale," a slide lecture by Durward Allen on the island's timber wolf population, in the auditorium, 8:00 P.M. Free to Participating, Donor, and Life Members; $2 for Associate Members and the public.

Saturday and Sunday, May 20 and 21; 1:00 to 4:30 P.M.: African Festival Weekend. Demonstrations of East African Bantu music and Liberian sculpture and presentations of African folk tales. Sunday at 2:00 P.M.: Babtunde Olatunji's troupe of dancers and drummers.

Sunday, May 28: "Film as a Research Tool in the Natural Sciences." Gotthard Wolf of the University of Göttingen, West Germany, will present two scientific films in the auditorium and discuss their uses in research and education: at 11:30 A.M., *Zoology and Behaviorism;* at 2:30 P.M., *Physiology and Botany.*

Ann Marie Cunningham



"There is nothing permanent except change."

Heraclitus

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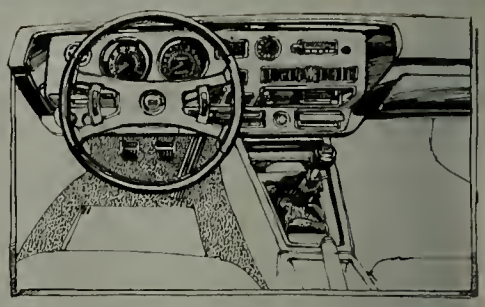
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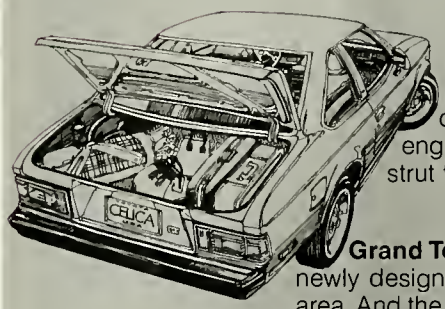
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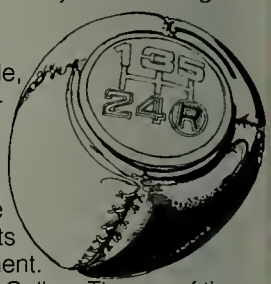




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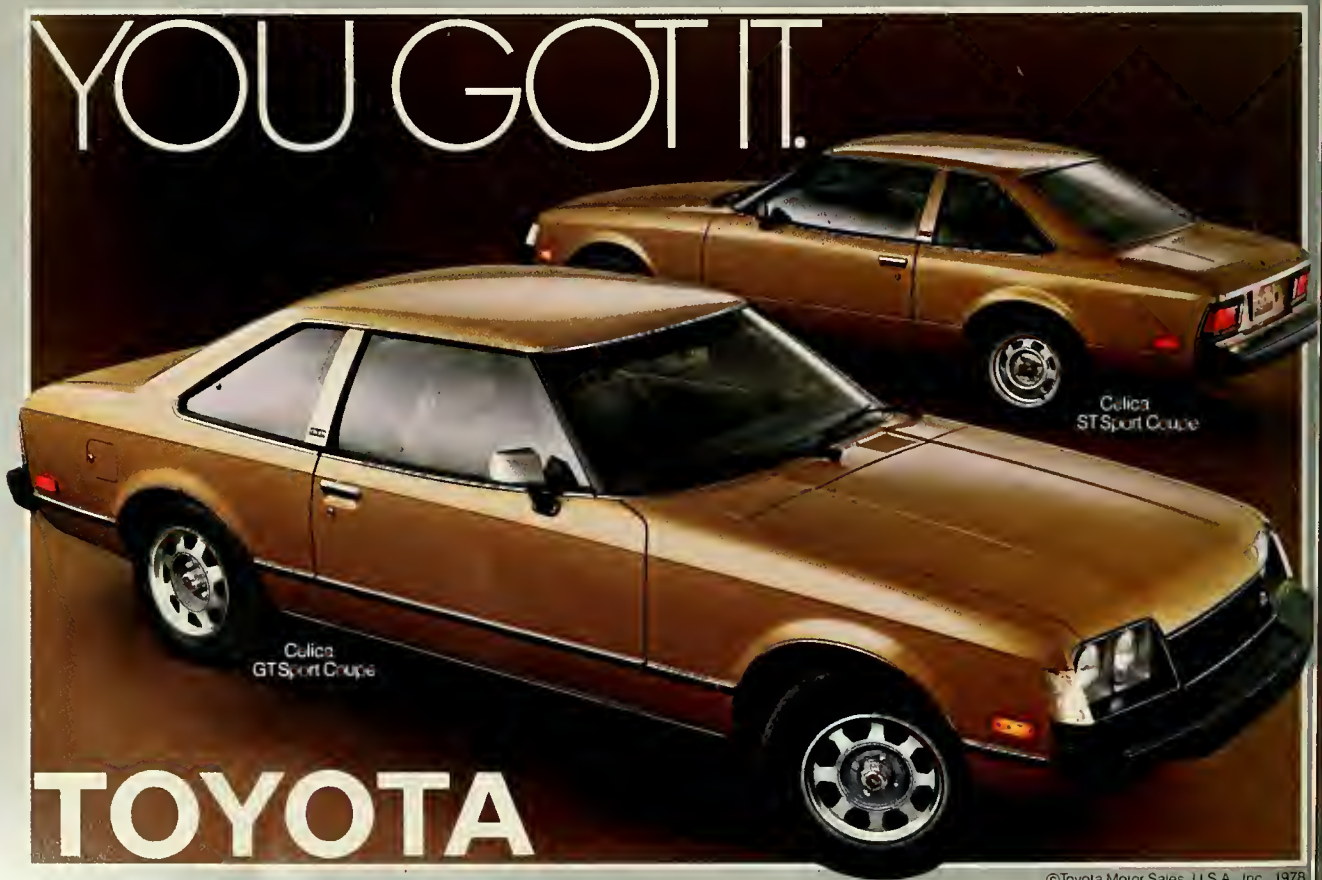
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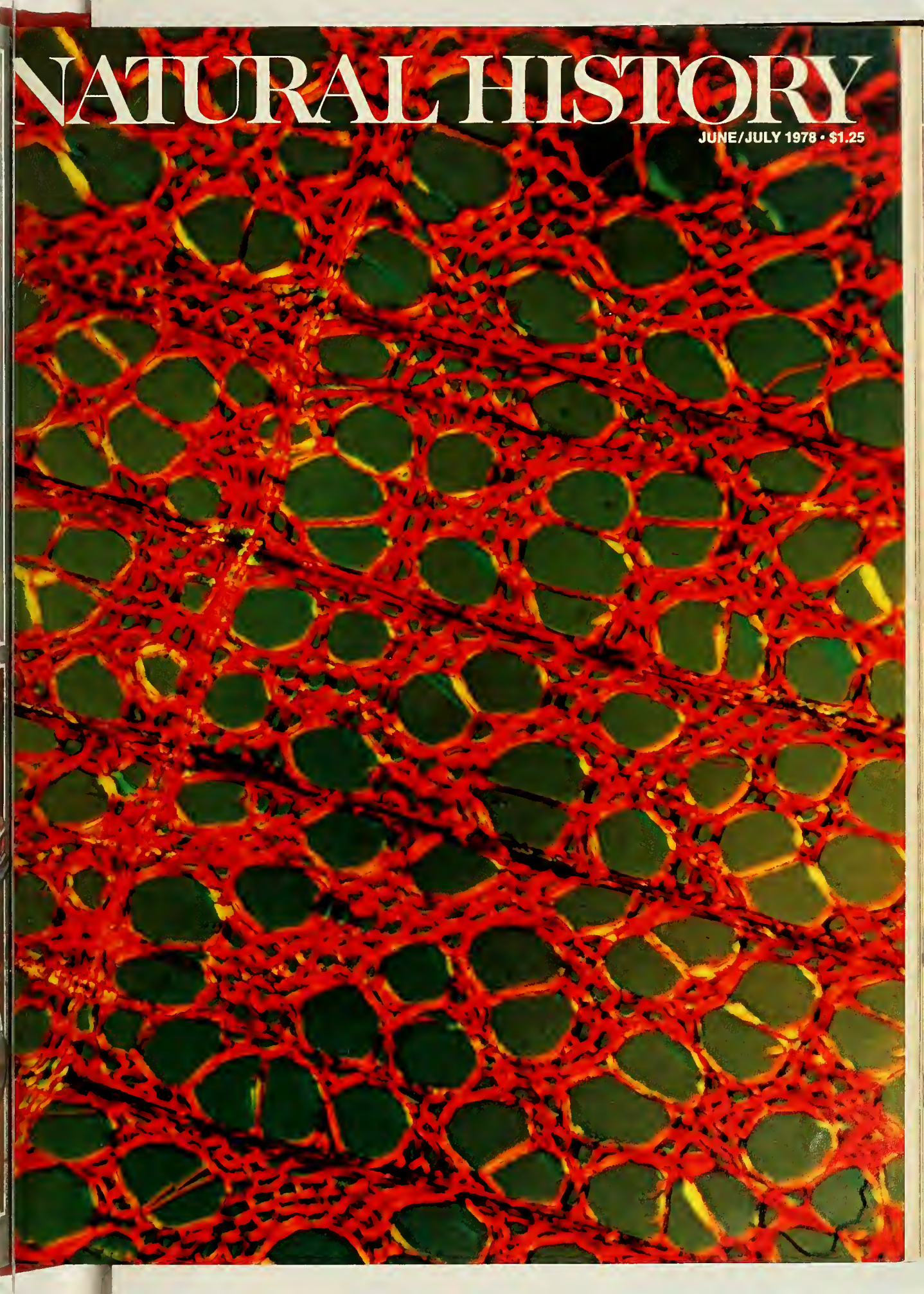


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NATURAL HISTORY

Incorporating Nature Magazine
Vol. LXXXVII, No. 6
June–July 1978

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Robert G. Goelet, President
Thomas D. Nicholson, Director

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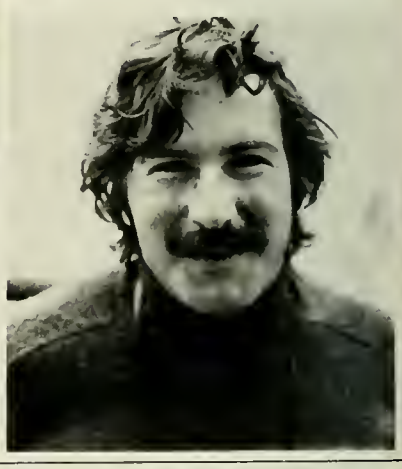
Philip C. Hammond has directed archeological expeditions to Petra, Hebron, and most recently to Tell el-Shuqafiyah in Egypt. Currently professor of anthropology at the University of Utah, he holds a bachelor of divinity degree in biblical literature from Drew University and a doctorate in Near Eastern archeology from Yale University. Hammond has written widely on religious and archeological subjects for various journals, including *Natural History*.





Michael Gochfeld combines the profession of biomedical research with an interest in avian behavioral ecology. As a teacher of environmental medicine at Columbia University School of Public Health, he includes in his investigations the effects of pollutants on sea bird populations. In one project he has focused on the tern colonies at Long Island's Jones Beach. He considers the intrusion of humans into the colonies to be as much of a pollutant as chemicals or debris. In addition to terns, Gochfeld is studying the behavioral ecology of other colonial sea birds, as well as the population structure of brown-headed cowbirds.

Photographer-geologist-naturalist **Allen Rokach** is a staff photographer for the *Algemeiner Journal* and supervisor of photography at the New York Botanical Garden. Rokach, who taught geology at the City University of New York, also serves as an instructor at the New School for Social Research, the American Museum of Natural History, and the Camera Club of New York. His articles and photographs have appeared in leading national publications.



Traditional fishing in the Caribbean is one of several investigative fields that interest anthropologist **John C. Cordell.** A postdoctoral fellow at the Department of Genetics, Stanford Medical Center, Cordell first visited northeastern Brazil's poverty-stricken fishing centers in 1963. Besides his research and writing on the fisheries, he has helped to establish rural health-care centers in Bahia and conducted research on Chinese acupuncture and herbal medicine.

On Photographing the Invisible

To the naked eye, it was a Swedish 80-ore postage stamp. A rarity, and very valuable.

The camera, however, told quite another story. The stamp was a counterfeit.

Faint traces of tampering that were hidden to the naked eye were revealed by the camera. Someone, somewhere, had ingeniously altered the stamp by chemically removing a surprint. The stamp was worthless.



To the naked eye (left), the stamp was genuine. To the camera (right), it was a counterfeit. Note the faint, dark traces of tampering now revealed in the upper section.

What manner of exotic camera was this that could "see" the invisible?

The lens: one of the 20 in the Hasselblad arsenal, the 105mm Zeiss UV-Sonnar f4.3. Designed for photography within the ultraviolet portion of the electromagnetic spectrum, its costly quartz elements can detect radiations that are unseeable by the human eye.

It has peered at objects in outer space, examined forgeries, laid bare the secrets of counterfeit money. Not a lens for everyone, obviously, but an indication of just how awesomely comprehensive the Hasselblad System is.

The camera: an otherwise perfectly standard Hasselblad 500C/M, normally fitted with an 80mm Zeiss Planar f2.8 multi-coated lens.

This is the basic model that allows you to tap into the vast Hasselblad System. It is one of the most bewilderingly versatile cameras the world has ever known. Yet so marvelously simple to operate that it often plays the part of the family snapshot camera.

A True System.

The Hasselblad System is a prodigious array of 4 cameras, 20 lenses, 8 viewfinders, 9 film magazines, and over 300 other accessories. Choose the right pieces, and your 500C/M would be equipped for sports, aerial, architectural, and fashion photography.

And portrait, landscape, medical, underwater, and news photography.

And wildlife, laboratory, industrial, and child photography.

And you would always have the right film in the camera at the right time. You can shift from color to black-and-white and back again to color—and resume shooting at precisely the right frame—by popping in the protective dark slide and switching film backs.

The Camera with Nine Backs.

There is a small button on the film back of every Hasselblad 500C/M. Slide it sideways with your thumb and the back will come away in your hand.

The standard back holds 12 exposures. Each frame of film is 2¼ inches square, *almost four times the area of a 35mm frame.* (See box, below right, for actual size.)

This is only the beginning. There are eight other backs available: Backs that let you change to a 6 x 4.5cm format...or a 4.5 x 4.5cm superslide format for showing in any 35mm projector. Backs that give you a choice of 1, 12, 16, 24, 70, or 500 exposures. A back that is a sheet-film adapter. Even two backs for Polaroid film, so you can check composition, lighting, and exposure ahead of time.

You begin to realize why eight out of ten top commercial photographers surveyed name Hasselblad as the medium-format camera used in their work.

Retained Value vs. Obsolescence.

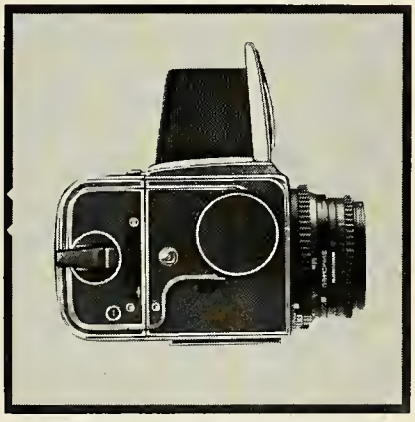
In an age when machines spew out cameras in the tens and hundreds of thousands, when flashy new models thrust last year's marvels into early obsolescence, Hasselblad goes its own way.

Planned obsolescence is taboo at Hasselblad. All but two of the accessories for the 500C/M will fit every Hasselblad made since 1957 (except the Super Wide C)...and will fit every future Hasselblad.

The greater part of a year is spent on building each camera, much of it crafted by hand. And fully one quarter of the work force devotes its time to nothing but quality control.

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"My personal approach to both research and teaching is to view the numerous details of an organism, no matter how small or specialized, in relation to how the organism must function to survive in nature." **Dan B. Walker** used this holistic approach in examining the adaptation of land plants to the atmosphere. For the past four years, Walker has been an assistant professor of botany at the University of Georgia, and he is now looking forward to his move on July 1 to the Department of Biology at the University of California, Los Angeles. Not surprisingly Walker has an avid interest in nature; he enjoys growing plants and "botanizing"—hiking into areas to observe unusual plants in their natural environment.

William J. Dederick teaches biology in Kingston, New York. "I first used photomicrographs in 1971 as part of a high school class lesson on plant anatomy. The slides seemed to give the students new interest in a rather dry subject." His photomicrographs are used on public television programs in the northeast and southeast. On weekends and during the summer, Dederick leaves biology behind by driving a Trailways bus.





Canadian-born **Calvin Martin** writes that he first became intrigued with Indian–land relationships during his boyhood "spent on a large country estate in eastern Canada." Later, in graduate school, he continued his youthful interest with studies in the biological sciences and ethnohistory. An assistant professor of history at Rutgers College, Martin plans to continue his research on Indian attitudes toward game resources and health and disease in American Indian societies. His book, *Keepers of the Game: Indian–Animal Relationships and the Fur Trade*, was published last month by the University of California Press.

In Memoriam

Some photographers whose pictures appear in *Natural History* are responding to assignments or requests; others take an active role in finding and photographing interesting subjects, and thereby spur our editors to recruit articles to go with the photographs.

Gail Rubin was one of the latter—imaginative, active, always finding new things to record with her camera. A former New York City fashion photographer who moved to Israel, Gail, in her visits to our office, often left behind sets of pictures that eventually became beautiful additions to the magazine. Her evocative desert wildlife photographs for "Ibex in Israel" (January 1978) and her abstract close-ups for "Eucalyptus Bark" (December 1977) are good examples.

And we are in her debt for this issue, too, since some of her pictures taken in Jordan moved us to commission the article on "Petra of the Nabataeans."

Dawn light in the Levant—where Gail chose to pursue her life as a photographer—has a special quality. On a morning in March she walked along the beach of a nature sanctuary in Israel, searching for wildlife to photograph. That she should discover, instead, a party of terrorists who had landed secretly, that they should question her and decide she would be dangerous to them if allowed to live, and that events from that moment on—in Israel and then Lebanon—would become more destructive and bloodier and bloodier is one of those ironies that tax human understanding.

Gail Rubin's well-used cameras were found in the sand next to her body.





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Seville
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Death Be Not Strange

by Peter A. Metcalf

As anthropologists learn to see other peoples' ways as natural, customs closer to home begin to seem exotic

The popular view of anthropology is that it is concerned with faraway places, strange peoples, and odd customs. This notion was neatly captured by a nineteenth-century wit who described the field as "the pursuit of the exotic by the eccentric." In recent decades many anthropologists have tried to shake this image. They see the exotic as dangerously close to the sensational and, therefore, a threat to the respectability of a serious academic discipline. They argue that anthropology has solid theoretical bases, and that some anthropologists routinely work in cities right here in America. And they are right. Nevertheless, anthropologists are as much involved with the exotic as ever, and I think that this concern actually works to scholarship's advantage.

This continuing involvement is a result of the characteristic *modus operandi* of anthropologists. First, we seek out the exotic, in the sense of something originating in another country or something "strikingly or excitingly different," as my *Webster's* puts it. Second, we try to fit this alien item—culture trait, custom, piece of behavior—into its social and cultural context, thereby reducing it to a logical, sensible, even necessary element. Having done that, we feel that we can understand why people do or say or think something instead of being divorced from them by what they say, think, or do.



The remains of Utan Nin, a Berawan woman, are displayed in the tribal longhouse

Peter A. Metcalf



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Then there's Omni's hatchback. Open it up, and you're confronted with a special storage compartment covered by a carpeted security panel. Into it you can put five, six, maybe seven bags of groceries. Four fully loaded golf bags. All kinds of odds and ends . . . all tucked nicely out of sight. Or, you can lift that hatchback, fold down the rear seat and security panel, and turn Omni into a station wagon with truly astounding cargo handling dimensions. For rocking chairs. Or fireplace wood. Or even playpens.



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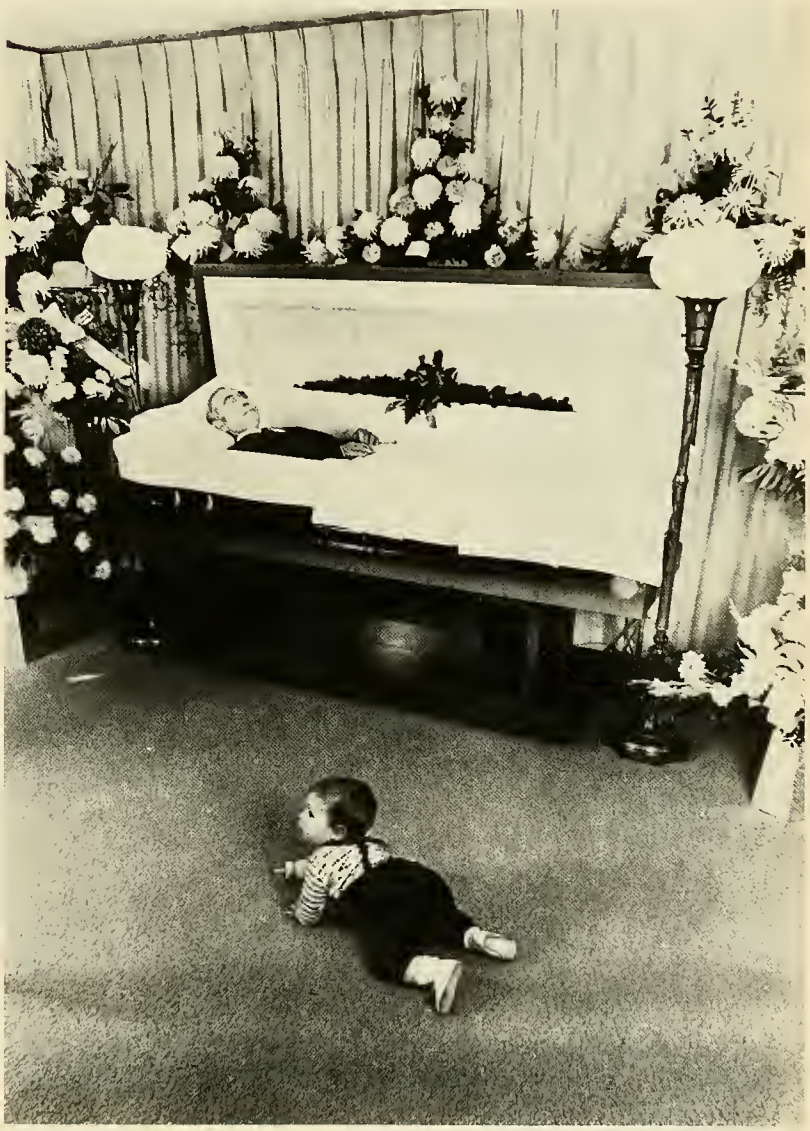
Sir James Frazer, whose classic study of primitive religions, *The Golden Bough,* was first published in 1890, provides an excellent example of the eccentric in pursuit of the exotic. For him, the process of reducing the mysterious to the commonplace was the very hallmark of scientific progress. Like many anthropologists of his time, Frazer assumed that some societies were superior and others inferior, and that anthropology's main task was to describe how the latter had evolved into the former. To Frazer, Europe's technological achievements were proof of social, intellectual, and moral superiority. The dominance of the West represented the triumph of science, which in Frazer's evolutionary schema, superseded even the most rational of world religions. Science's clear light was to shine far and wide, driving superstition, the supernatural, and even God himself back into shadows and dimly lit corners.

But Frazer might have found a second aspect of the anthropological *modus operandi* less to his taste. In the course of making sense of someone else's behavior or ideas, we frequently begin to observe our own customs from a new angle. Indeed, this reflexive objectivity is often acclaimed as one of the great advantages of our methods and cited as a major justification for the long, expensive physical and psychic journeys that we make, seeking out societies far removed from our own cultural traditions. Less often remarked upon, however, is that the exotic possesses its own reflexive quality. As we learn to think of other peoples' ways as natural, we simultaneously begin to see our own as strange. In this sense, anthropologists import the exotic, and that, I suppose, puts us on the side of the angels.

An incident that occurred about four years ago during my fieldwork in north-central Borneo brought home to me the depth and subtlety of anthropologists' involvement with the exotic. I was working with the Berawan, a small tribe comprising four communities, each made up of several hundred people living in a massive wooden longhouse. The four longhouses stand beside the great rivers that are the only routes into the interior of Borneo. Berawan communities live on fish and on rice planted in clearings cut anew in the rain forest each year. In the late nineteenth century, which was a stormy period of tribal warfare, each longhouse was a fortress as well as a home, and the Berawan look back with pride on the military traditions of that era.

Among the things that interested me about the Berawan were their funeral rites, which involve what anthropologists call "secondary burial," although the Berawan do not usually bury the dead at all. Full rites consist of four stages: the first and third involve ritual preparation of the corpse; the second and fourth make up steps in storage of the remains. The first stage, lasting two to ten days, consists of rites performed immediately after death. During the second stage, the bereaved family stores the corpse in the longhouse or on a simple platform in the graveyard. This storage lasts at least eight months and sometimes for several years if the close kin cannot immediately afford to complete the expensive final stages. Third, if the corpse has been in the graveyard, the family brings it back to the longhouse, where it is kept for six to ten days, while the family lavishly entertains guests who have been summoned from far and wide. Finally, the remains are removed to a final resting place, an impressively proportioned mausoleum.

Within this four-part plan, details of the corpse's treatment vary considerably. During the first storage



The photographer's grandfather lies in a funeral home in Pennsylvania. Mark Jury



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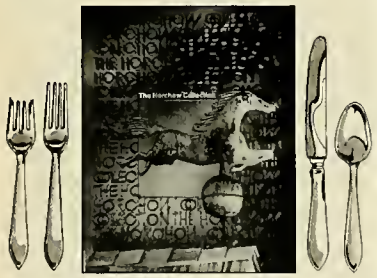
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stage, the family may place the corpse in large earthenware jars or in massive coffins hewn from a single tree trunk. For secondary storage, the family may use valuable glazed jars or the coffin left over from the first stage. During the third-stage rites, the family may take out the bones of the deceased and clean them. As the corpse decomposes, its secretions may be collected in a special vessel. Some neighbors of the Berawan reportedly consume liquids of decomposition mixed with rice—a variety of endocannibalism.

For anthropologists, this intimate interaction with the corpse is certainly exotic. For Americans not professionally trained in the niceties of cultural relativism, Berawan burial is no doubt disgusting: keeping corpses around the house, shuttling them between the graveyard and the longhouse, storing them aboveground instead of burying them, manipulating the bones, and, to Western eyes, paying macabre attention to the process of decay itself. My Berawan informants were aware that some phases of their ritual bothered Europeans. They soon learned, moreover, that I had a lot of questions about their funerals. One of the pleasures of working in Borneo is that people soon begin to cross-examine their interviewer. They are as curious about the stranger as he or she is about them. So before long, they began to quiz me about the death ways of my country.

On one memorable occasion, during a lull in ritual activity, I responded to one of these questions by outlining American embalming practices—the treatment of the corpse with preservative fluids and its display in an open coffin. I was well into my story, concentrating on finding the right words to describe this unfamiliar topic, when I became aware that a sudden silence had fallen over my audience. They asked a number of hesitant questions just to be sure that they had understood me correctly and drew away from me in disgust when they found that they had. So shocked were they that I had to backtrack rapidly and change my story. The topic was never broached again.

At the time, I did not understand why American embalming practices had so unnerved the Berawan. Now, having thought about the meaning of Berawan death rituals, I think that I do understand.

The death rituals of central Borneo early attracted the interest of explorers and ethnologists. In 1907, Robert Hertz, a young student of French sociologist Émile Durkheim, wrote an essay about these rites that has become a classic. Never having set foot in Borneo, Hertz relied on the accounts of travelers. Had he not been killed during the First World War, he might well have undertaken firsthand research himself. Nevertheless, his analysis is still routinely cited in discussions and comparisons of funeral customs. Yet, oddly, Hertz's central thesis has received very little attention. Hertz hypothesized that peoples who practice secondary burial have certain beliefs about the afterlife, namely, that the fate of the body provides a model for the fate of the soul.

Since Hertz did not know of the Berawan, they provided me with an appropriate test case for his hypothesis. I collected data on everything related to Berawan death rites: the people involved, mourning practices, related rituals, myths and beliefs, and so on. I also pressed my informants for interpretations of rituals. All the material I accumulated revealed a consistent set of ideas very similar to those described by Hertz. The Berawan believe that after death the soul is divorced from the body and cannot reanimate the already decaying corpse. However, the soul cannot enter the land of the dead because it is not yet a perfect spirit. To become one of the truly dead, it must undergo a metamorphosis. As the body rots away to leave dry bones, so the soul is transformed slowly into spirit form. As the corpse is formless and repulsive until putrefaction is completed, so the soul is homeless. It lurks miserably on the fringes of human habitation and, in its discomfort, may affect the living with illness. The third stage of the mortuary sequence, which Hertz called the "great feast," marks the end of this miserable period. The soul finally passes to the land of the dead, and the mortal remains of the deceased join those of its ancestors in the tomb.

But before this happy conclusion is reached, the hovering soul is feared because it may cause more death. Even more dread surrounds

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the body itself, caused not by the process of rotting, for that releases the soul of the deceased from the bonds of the flesh, but by the possibility that some malignant spirit of nonhuman origin will succeed in reanimating the corpse. Should this occur, the result will be a monster of nightmarish mien, invulnerable to the weapons of men, since it is already dead.

I once witnessed an incident that dramatically demonstrated how real is the Berawan fear of reanimated corpses. Toward sunset, a group of mourners and guests were chatting casually beside a coffin that was being displayed on the longhouse veranda in preparation for primary storage. Suddenly there was a tapping sound, apparently from inside the coffin. The noise could have come from the house timbers, contracting in the cool of the evening, but the people present saw a different explanation. After a moment of shock, the women fled, carrying their children. Some panic-stricken men grabbed up what weapons were handy, while others tied up the coffin lid with yet more bands of rattan. Calm was not restored until later in the evening when a shaman investigated and declared that nothing was amiss.

We can now see why American mortuary practices so shock the Berawan. By delaying the decomposition of corpses, we commit a most unnatural act. First, we seem to be trying to trap our nearest and dearest in the unhappiest condition possible, neither alive nor in the radiant land of the dead. Second, and even more perverse and terrifying, we keep an army of undecomposed corpses, each and every one subject to reanimation by a host of evil spirits. For the Berawan, America is a land carpeted with potential zombies.

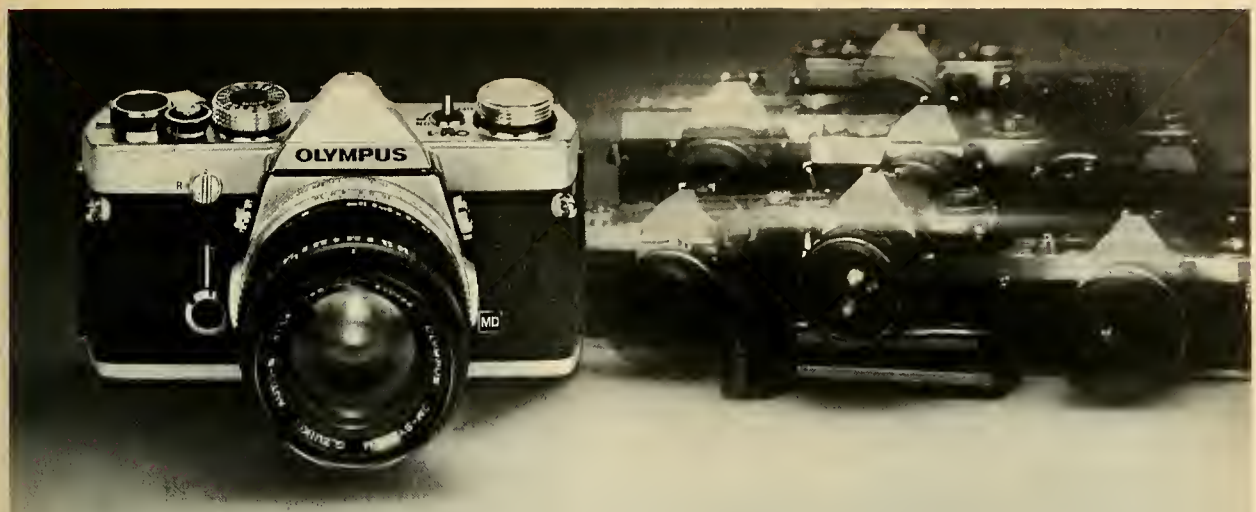
After a couple of years of fieldwork, and an application of the ideas of Hertz and others, I can offer a relatively full account of Berawan death ways: what they express about Berawan notions of life and death; how they are manipulated by influential men in their struggles for power; how they relate to their sense of identity, art forms, and oral history. Meanwhile, I have also explored the literature on American death ways—and have found it wanting. For the most part, it is restricted to consideration of psychological variables—how people react to death, either the possibility of their own or that of close relatives and friends. None of these studies begins to explain why American funerals are the way they are; why they differ from British funerals, for instance.

Jessica Mitford, author of *The American Way of Death,* tried to explain the form that American funerals take by arguing that they are a product of the death industry's political power. But Mitford's theory does not explain the tacit support that Americans give to this institution, why successive immigrant groups have adopted it, or why reform movements have failed.

I have tried to relate American practices to popular ideas about the nature of a fulfilling life and a proper death. Despite these intellectual efforts, I am left with a prickly sense of estrangement. For, in fact, I had spared my Berawan friends the more gruesome details of embalming: replacement of the blood with perfumed formaldehyde and other chemicals; removal of the soft organs of the chest and abdomen via a long hollow needle attached to a vacuum pump; injection of inert materials. I did not mention the American undertaker's elaborate restorative techniques: the stitching up of mutilated corpses, plumping out of emaciated corpses with extra injections of waxes, or careful cosmetic care of hands and face. Nor did I tell the Berawan about the padded coffins, grave clothes ranging in style from business suits to negligees, and other funeral paraphernalia. Had I explained all this, their shock might have been transformed into curiosity, and they might have reversed our roles of social scientist and informant.

In the meantime, something of their reaction has rubbed off on me. I have reduced the celebrated mortuary rites of remote and mysterious Borneo to a kind of workaday straightforwardness, only to be struck by the exotic character of an institution in our very midst.

Peter A. Metcalf, assistant professor of anthropology at the University of Virginia, is coauthor, with Richard Huntington, of the forthcoming Burial and Re-burial: An Anthropological Analysis of the Funeral.



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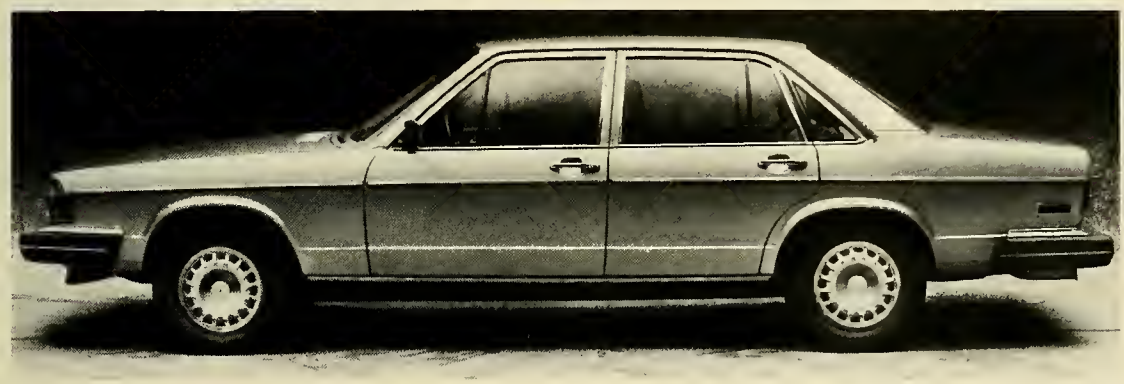
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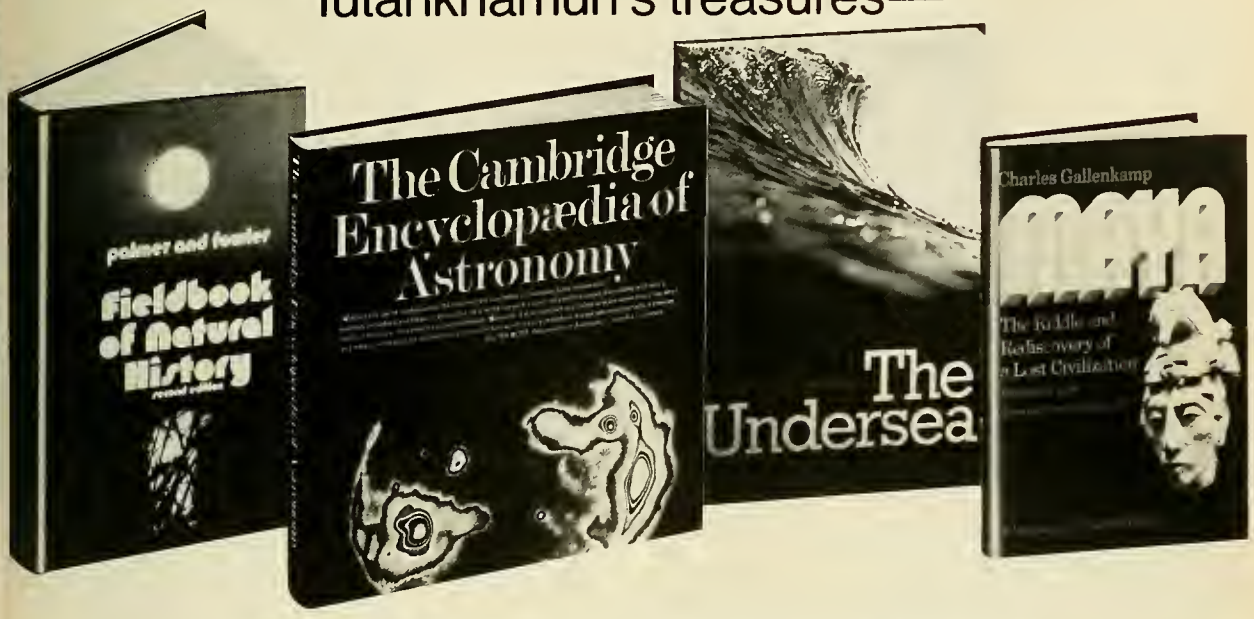
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WITH WHAT MINOLTA KNOWS ABOUT CAMERAS AND WHAT YOU KNOW ABOUT YOURSELF, WE CAN MAKE BEAUTIFUL PICTURES TOGETHER.

If you've considered buying a 35mm single lens reflex camera, you may have wondered how to find the right one out of the bewildering array of models and features available.

And with good reason, since the camera you choose will have a lot to do with how creative and rewarding your photography will be.

What you pay for your camera shouldn't be your only consideration, especially since there are some very expensive cameras that won't give you some of the features you really need. So ask yourself how you'll be using the camera and what kind of pictures you'll be taking. Your answers could save a lot of money.

How automatic should your camera be?

Basically, there are two kinds of automatic 35mm SLR's. Both use advanced electronics to give you perfectly exposed pictures with point, focus and shoot simplicity. The difference is in creative control.

For landscapes, still lifes, portraits and the like, you'll want an *aperture-priority* camera. It lets *you* set the lens opening, while *it* sets the shutter speed automatically.

This way, you control depth-of-field. That's the area of sharpness in front of and behind your subject. Many pro photographers believe that depth-of-field is the most important factor in creative photography.

At times you may want to control the motion of your subject. You can do this with an aperture-priority camera by changing the lens opening until the camera sets the shutter speed necessary to freeze or blur a moving subject. Or you can use a *shutter-priority* camera, on which you set the shutter speed first and the camera sets the lens automatically.

Minolta makes both types of automatic cameras. The Minolta XG-7 is moderately priced and offers aperture-priority automation, plus fully manual control. The Minolta XD-11 is somewhat more expensive, but it offers all the creative flexibility of both aperture and shutter-priority automation, plus full manual control. The XD-11 is so advanced that during shutter-priority operation it will actually make exposure corrections you fail to make.

Do you really need an automatic camera?

Automation makes fine photography easier. But if you do some of the work yourself, you can save a lot of money and get pictures every bit as good.

In this case, you might consider a Minolta SR-T. These are semi-automatic cameras. They have built-in, through-the-lens metering systems that tell you exactly how to set the lens and shutter for perfect exposure. You just align two indicators in the viewfinder.

What to expect when you look into the camera's viewfinder.

The finder should give you a clear, bright view of your subject. Not just in the center, but even along the edges and in the corners. Minolta SLR's have bright finders, so that composing and focusing are effortless, even in dim light. And focusing aids in Minolta

Minolta makes all kinds of 35mm SLR's, so our main concern is that you get exactly the right camera for your needs. Whether that means the advanced Minolta XD-11. Or the easy-to-use and moderately priced Minolta XG-7. Or the very economical Minolta SR-T cameras.





Automatic sequence photography is easy when you combine a Minolta XD-11 or XG-7 with optional Auto Winder and Electroflash 200X.

viewfinders make it easy to take critically sharp pictures.

Information is another thing you can expect to find in a well-designed finder. Everything you need to know for a perfect picture is right there in a Minolta finder.

In the Minolta XD-11 and XG-7, red light emitting diodes tell you what lens opening or shutter speed is being set automatically and warn against under or over-exposure. In Minolta SR-T cameras, two pointers come together as you adjust the lens and shutter for correct exposure.

Do you need an auto winder?

You do if you like the idea of sequence photography, or simply want the luxury of power assisted film advancing. Minolta auto winders will advance one picture at a time, or continuously at about two per second. With advantages not found in others, like up to 50% more pictures with a set of batteries and easy attachment to the camera without removing any caps. Optional auto winders are available for both the Minolta XD-11 and XG-7, but not for Minolta SR-T cameras.

How about electronic flash?

An automatic electronic flash can be added to any Minolta SLR for easy, just about foolproof indoor photography without the bother of flashbulbs. For the XD-11 and XG-7, Minolta makes the Auto Electroflash 200X. It sets itself automatically for flash exposure, and it sets the camera automatically for use with flash. An LED in the viewfinder signals when the 200X is ready to fire. Most unusual: the Auto Electroflash 200X can fire continuously in perfect synchronization with Minolta auto winders. Imagine being able to take a sequence of 36 flash pictures without ever taking your finger off the button.

You should be comfortable with your camera.

The way a camera feels in your hands can make a big difference in the way you take pictures.

The Minolta XD-11 and XG-7, for instance, are compact, but not cramped. Lightweight, but with a solid feeling of quality. Oversized controls are positioned so that your fingers fall naturally into place. And their electronically controlled shutters are incredibly smooth and quiet.

Minolta SR-T's give you the heft and weight of a slightly larger camera, but with no sacrifice in handling convenience. As in all Minolta SLR's, "human engineering" insures smooth, effortless operation.



Are extra features important?

If you use them, there are a lot of extras that can make your photography more creative and convenient. Depending on the Minolta model you choose, you can get: multiple exposures with pushbutton ease (even with an auto winder). A window to show that film is advancing properly. A handy memo holder that holds the end of a film box to remind you of what film you're using. And a self-timer.

What about the lens system?

The SLR you buy should have a system of lenses big enough to satisfy your needs, not only today, but five years from today. The patented Minolta bayonet mount lets you change lenses with less than a quarter turn. There are almost 40 Minolta lenses available, ranging from 7.5mm fisheye to 1600mm super-telephoto, including macro and zoom lenses and the world's smallest 500mm lens.



The electronic viewfinder: LED's tell you what the camera is doing automatically to give you correct exposure.



The match-needle viewfinder: just align two indicators for correct exposure. Because you're doing some of the work, you can save some money.

What's next?

Think about how you'll use your camera and ask your photo dealer to let you try a Minolta. Compare it with other cameras in its price range. You'll soon see why more Americans buy Minolta than any other brand of SLR. For literature, write Minolta Corp., 101 Williams Drive, Ramsey, New Jersey 07446. In Canada: Minolta Camera (Canada) Inc., Ontario.

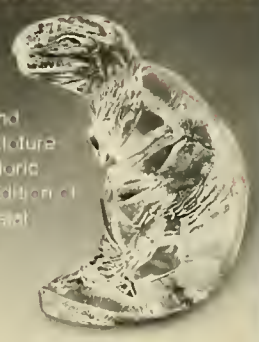
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statesmanship, wisdom, and rectitude.

I write this column in the structure that Louis Agassiz built in 1859—the original wing of Harvard's Museum of Comparative Zoology. Agassiz, the world's leading student of fossil fishes, protégé of the great Cuvier, left his native Switzerland for an American career in the late 1840s. As a celebrated European and a charming man, Agassiz was lionized in social and intellectual circles from Boston to Charleston. He led the study of natural history in America until his death in 1873.

Louis's public utterances were always models of propriety, but I expected that his private letters would match his ebullient personality. Yet Elizabeth's book, ostensibly a verbatim report of these letters, manages to turn this focus of controversy and source of restless energy into a most measured and dignified gentleman.

Recently, in studying Louis Agassiz's views on race, I discovered several interesting discrepancies between Elizabeth's version and the original letters. Elizabeth simply expurgated the text and didn't even insert ellipses to indicate her deletions. Harvard has the original letters, and a bit of sleuthing on my part turned up some spicy material.

But first, Agassiz's public stance on human races. During the decade before the Civil War, Agassiz expressed strong opinions on the status of blacks and Indians. As an adopted son of the north, he rejected slavery, but as an upper-crust Caucasian, he certainly didn't link this rejection to any notion of racial equality.

Agassiz presented his racial attitudes as sober and ineluctable deductions from first principles. Species are static, created entities (at his death in 1873, Agassiz stood virtually alone among biologists as a holdout against the Darwinian tide). They are not placed upon the earth in a single spot, but created simultaneously over the entire range of their habitation. Related species are often placed in separate geographic regions, each adapted to prevailing environments of its own area. Since human races met these criteria before commerce and migration mixed us up, each race is a separate biological species.

Thus, America's leading biologist came down firmly on the wrong side of a debate that had been raging in America for a decade before he arrived: Was Adam the progenitor of all people or only of white people? Are blacks and Indians our brothers or merely our look-alikes? In logic, separate needn't mean unequal, as the victors in Plessy v. Ferguson argued in 1896. But, as the winners in Brown v. the Topeka Board of Education maintained in 1954, a group in power always conflates separation with superiority. In fact, I know of no American "polygenist"—as advocates of separate species called themselves—who did not assume that whites were separate *and* superior.

Agassiz insisted that his defense of polygeny had nothing to do with political advocacy or social prejudice. He was, he argued, merely a humble and disinterested scholar:

> It has been charged upon the views here advanced that they tend to the support of slavery. . . . Is that a fair objection to a philosophical investigation? Here we have to do only with the question of the origin of men; let the politicians, let those who feel themselves called upon to regulate human society, see what they can do with the results. . . . We disclaim all connection with any question involving political matters. . . . Naturalists have a right to consider the questions growing out of men's physical relations as merely scientific questions, and to investigate them without reference to either politics or religion.

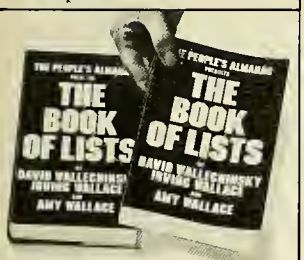
Despite these brave words, Agassiz ends this major statement on race (published in the *Christian Examiner*, 1850) with some definite social recommendations. First he affirms the doctrine of separate and unequal: "There are upon earth different races of men, inhabiting different parts of its surface . . . and this fact presses upon us the obligation to settle the relative rank among these races." The resultant hierarchy is self-evident: "The indomitable, courageous, proud Indian—in how different a light he stands by the side of the submissive, obsequious, imitative negro, or by the side of the tricky, cunning, and cowardly Mongolian! Are not these facts indications that the different races do not rank upon one level in nature." Finally, if he hadn't made his political message clear by generalization, Agassiz ends by advocating specific social policy—thus contravening his original pledge to abjure politics for the

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pure life of the mind. Education, he argues, must be tailored to innate ability; train blacks in hand work, whites in mind work.

What would be the best education to be imparted to the different races in consequence of their primitive difference. . . . We entertain not the slightest doubt that human affairs with reference to the colored races would be far more judiciously conducted if, in our intercourse with them, we were guided by a full consciousness of the real differences existing between us and them, and a desire to foster those dispositions that are eminently marked in them, rather than by treating them on terms of equality.

Since these "eminently marked" dispositions are submissiveness, obsequiousness, and imitation, we can well imagine what Agassiz had in mind.

Agassiz had political clout, largely because he spoke as a scientist, supposedly motivated only by the facts of his case and the abstract theory they embodied. In this context, the actual source of Agassiz's ideas on race becomes a matter of some importance. Did he really have no ax to grind, no predisposition, no impetus beyond his love for natural history? The deleted passages from *Life and Correspondence* shed considerable light. They show a man with strong prejudices based primarily on immediate visceral reactions and deep sexual fears.

The first passage, almost shocking in its force, even 130 years later, recounts Agassiz's first experience with black people (he had never encountered blacks in Europe). He first visited America in 1846 and sent his mother a long letter detailing his experiences. In the section on Philadelphia, Elizabeth Agassiz records only his visits to museums and the private homes of scientists. She expunges, without ellipsis, his first impression of blacks—a visceral reaction to black waiters in a hotel restaurant. In 1846 Agassiz still believed in human unity, but this passage exposes an explicit, stunningly nonscientific basis for his conversion to polygeny. For the first time, then, without ellipsis:

It was in Philadelphia that I first found myself in prolonged contact with negroes; all the domestics in my hotel were men of color. I can scarcely express to you the painful impression that I received, especially since the sentiment that they inspired in me is contrary to all our ideas about the confraternity of the human type and the unique origin of our species. But truth before all. Nevertheless, I experienced pity at the sight of this degraded and degenerate race, and their lot inspired compassion in me in thinking that they are really men. Nonetheless, it is impossible for me to repress the feeling that they are not of the same blood as us. In seeing their black faces with their thick lips and grimacing teeth, the wool on their head, their bent knees, their elongated hands, their large curved nails, and especially the livid color of the palms of their hands, I could not take my eyes off their faces in order to tell them to stay far away. And when they advanced that hideous hand towards my plate in order to serve me, I wished I were able to depart in order to eat a piece of bread elsewhere, rather than to dine with such service. What unhappiness for the white race—to have tied their existence so closely with that of negroes in certain countries! God preserve us from such a contact!

The second set of documents comes from the midst of the Civil War. Samuel Howe, husband of Julia Ward Howe (author of *The Battle Hymn of the Republic*) and a member of President Lincoln's Inquiry Commission, wrote to ask Agassiz his opinion about the role of blacks in a reunited nation. During August 1863, Agassiz responded in four long and impassioned letters. Elizabeth Agassiz bowdlerized them to render Louis's case as a soberly stated opinion (despite its bizarre content), derived from first principles and motivated only by a love of truth.

Louis argued, in short, that races should be kept separate lest white superiority be diluted. This separation should occur naturally since mulattoes, as a weak strain, will eventually die out. Blacks will leave the northern climates so unsuited to them (since they were created as a separate species for Africa); they will move south in droves and will eventually prevail in a few lowland states, although whites will maintain dominion over the seashore and elevated ground. We will have to recognize these states, even admit them to the Union, as the best solution to a bad situation; after all, we do recognize "Haity and Liberia."

Elizabeth's substantial deletions display Louis's motivation in a very different light. They radiate raw fear and blind prejudice. She systemat-

Please turn to page 26

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LOUISIANA, Beton Rouge: Norckeuer Assoc., Stineburgs Sports Center. **Chelmette:** Old River Specialty Co **Hahnville:** Spartan Supply Co. **Lafayette:** Lafayette Shooter Supply **Lake Cherles:** House of Sports **New Orleans:** Baker Lyman & Co., Sea-Trec Marine Center

MAINE, Auburn: Eastern Mountain Sports **Kittery:** Kittery Trading Post.

MARYLAND, Easton: Crawford Enterprises - Books and Boats. **Glen Burnie:** Hilton Boat Sales

MASSACHUSETTS, Boston: Eastern Mountain Sports, F. C. Meichsner Co., Inc., Park Square Camera & Photo, Inc Stoddards, Inc., **Hadley:** Eastern Mountain Sports **Lansaboro:** Fran's Archery & Guns.

MICHIGAN, Algonac: Chris Craft Corp **Birmingham:** The Sportsman, **Dearborn:** Nichols Sports & Marine. **Detroit:** Tuckerman Optical **Hastings:** Western Outfitters, Inc **Lansing:** Lieberman's of Michigan. **Oak Park:** Eddie Bauer, Inc. **Traverse City:** Hampel's

MINNESOTA, Bemidji: Xen's North Country Sporting Goods **Bloomington:** Burger Bros., Inc. **Duluth:** Duluth Camera Exchange **Minneapolis:** Benson Optical Co., Brown Photo, National Camera Exchange, North Central Instruments **Spicer:** Mel's Sport Shop **St. Paul:** Gokey Co. **Wayzata:** Gokey-Wayzata.

MISSISSIPPI, Meridian: Outdoor World

MISSOURI, Kansas City: Hall's Crown Center **St. Joseph:** Hatfield's Sporting Goods **St. Louis:** Casey's Enterprises, Inc.

MONTANA, Billings: Johnson Opticians, Odegaards **Helena:** Capital Sporting Goods & Western Wear **Great Falls:** Tandy Leather Co **Missoula:** Bob Ward & Sons

NEBRASKA, Ceresco: Paul's Cartridge Corner c/o Ernie's Store, Inc **Omaha:** Canfield's Inc **Seward:** Plum Creek Gun Shop, Inc **Sidney:** Cabela's, Inc

NEVADA, Las Vegas: Adams Feed Co. & Western Wear **Reno:** Alpine Reloading Room, Johnson Sporting World

NEW HAMPSHIRE, Hooksett: Riley's Sport Shop **Hudson:** Pete's Gun and Tackle **No. Conway:** Eastern Mountain Sports **Peterborough:** Eastern Mountain Sports **Penecook:** Marshall Firearms **Troy:** Buzz Bowers Sportsmens Den.

NEW JERSEY, Berrington: Edmund Scientific **Bound Brook:** Effinger Sporting Goods. **Garfield:** S Meltzer & Sons, Inc **Hackenseck:** Eastern Mountain Sports **Pennsauken:** Leslie Edelman, Inc **Pequennock:** Sportsmen's Den **Princeton:** The Nickel **Wayne:** Leslie Edelmen, Inc.

NEW MEXICO, Bordentown: Sportsmen's Center **Las Cruces:** The Rustic Rifle, Ltd **Sante Fe:** Tranos Sporting Goods.

NEW YORK, Amsterdam: H. E Gibbs. **Ardsley:** Eastern Mountain Sports. **Binghamton:** Tutthill's Photo Center, Inc **Brooklyn:** Karnival Sports Center **Carle Place:** Eastern Mountain Sports **Croghen:** Collins F Kellogg **Farmingdale:** Leslie Edelman, Inc., World of Guns. **Lake Placid:** Eastern Mountain Sports. **New Hyde Park:** Leslie Edelman, Inc. **New York City:** Cambridge Camera Exchange, Camera Discount Center, Clairmount Nichols Optician, Competitive Camera, Forty Seventh St. (47th) Photo, Inc., Lugene, Inc. E B Meyrowitz, Inc , N.Y Nautical Instrument & Service Corp., H L Purdy, Inc., Rensay Trading Corp., Wall St Camera Exchange. **Rochester:** The Archery Outfitters, Photogenesis Camera Center. **Solvay:** Solvay Home & Outdoor Center **Syracuse:** M O Camera Center **Tonewende:** Eastern Mountain Sports **White Plains:** Male-Town, Inc

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PENNSYLVANIA, Allquippe: Queen City Distributing Co **Allentown:** Leslie Edelman, Inc. **Bethel Park:** Bethel Park Optique, Inc. **Fairless Hills:** Leslie Edelman, Inc **Freeland:** Herring's Sporting Goods **Jenkintown:** Paul Jaeger, Inc. **Media:** House of Stewart. **Montgomeryville:** Leslie Edelman, Inc. **New Town Squere:** Leslie Edelman, Inc. **Philadelphia:** I. Miller. **Phillpsburg:** Belding & Mull. **Pitcairn:** Esman's **Southempton:** Nationwide Sports Distributors, Inc **Reading:** Alton E. Bowers Photo Service **West Reading:** Wiest's Sporting Goods. **Wilkes Berre:** Danoff's Sporting Goods

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Henry E. Gardiner



ically eliminates three kinds of statements. First, she omits the most denigrating references to blacks: "In everything unlike other races," Louis writes, "they may but be compared to children, grown in the stature of adults, while retaining a childlike mind." Second, she removes all elitist claims about the correlation of wisdom, wealth, and social position within races. In these passages, we begin to sense Louis's real fears about miscegenation.

I shudder from the consequences. We have already to struggle, in our progress, against the influence of universal equality, in consequence of the difficulty of preserving the acquisitions of individual eminence, the wealth of refinement and culture growing out of select associations. What would be our condition if to these difficulties were added the far more tenacious influences of physical disability. Improvements in our system of education . . . may sooner or later counterbalance the effects of the apathy of the uncultivated and of the rudeness of the lower classes and raise them to a higher standard. But how shall we eradicate the stigma of a lower race when its blood has once been allowed to flow freely into that of our children.

Third, and of greatest significance, she expunges several long passages on interbreeding that place the entire correspondence in a different setting from the one she fashioned. In them, we grasp Louis's intense, visceral revulsion toward the idea of sexual contact between races. This deep and irrational fear was as strong a driving force within him as any abstract notion about separate creation: "The production of half-breeds," he writes, "is as much a sin against nature, as incest in a civilized community is a sin against purity of character. . . . I hold it to be a perversion of every natural sentiment."

So strong is this natural aversion that abolitionist sentiment cannot reflect any innate sympathy for blacks but must arise because many "blacks" have substantial amounts of white blood and whites instinctively sense this part of themselves: "I have no doubt in my mind that the sense of abhorrence against slavery, which has led to the agitation now culminating in our civil war, has been chiefly if unconsciously fostered by the recognition of our own type in the offspring of southern gentlemen, moving among us as negros [*sic*], which they are not."

But if races naturally repel each other in matters sexual, how then do "southern gentlemen" take such willing advantage of their bonded women? Agassiz blames the mulatto house slaves. Their whiteness renders them attractive; their blackness, lascivious. The poor, innocent young men are enticed and entrapped.

> As soon as the sexual desires are awakening in the young men of the South, they find it easy to gratify themselves by the readiness with which they are met by colored [mulatto] house servants. [This contact] blunts his better instincts in that direction and leads him gradually to seek more spicy partners, as I have heard the full blacks called by fast young men. One thing is certain, that there is no elevating element whatever conceivable in the connection of individuals of different races; there is neither love, nor desire for improvement of any kind. It is altogether a physical connection.

How a previous generation of gentlemen overcame their aversion to produce the first mulattoes, we are not told. We cannot know in detail why Elizabeth chose her deletions. I doubt that a conscious desire to convert Louis's motives from prejudice to logical implication prompted all her actions. Simple Victorian prudery probably led her to reject a public airing of any statement about sex. In any case, her deletions did distort Louis Agassiz's thought and did render his intentions according to the fallacious and self-serving model favored by scientists—that opinions arise from dispassionate surveys of raw information.

These restorations show that Louis Agassiz was jolted to consider the polygenist theory of races as separate species by his initial, visceral reaction to contact with blacks. They also demonstrate that his extreme views on racial mixing were powered more by intense sexual revulsion than by any abstract theory of hybridity.

Racism has often been buttressed by scientists who present a public façade of objectivity to mask their guiding prejudices. Agassiz's case may be distant, but its message rings through our century as well.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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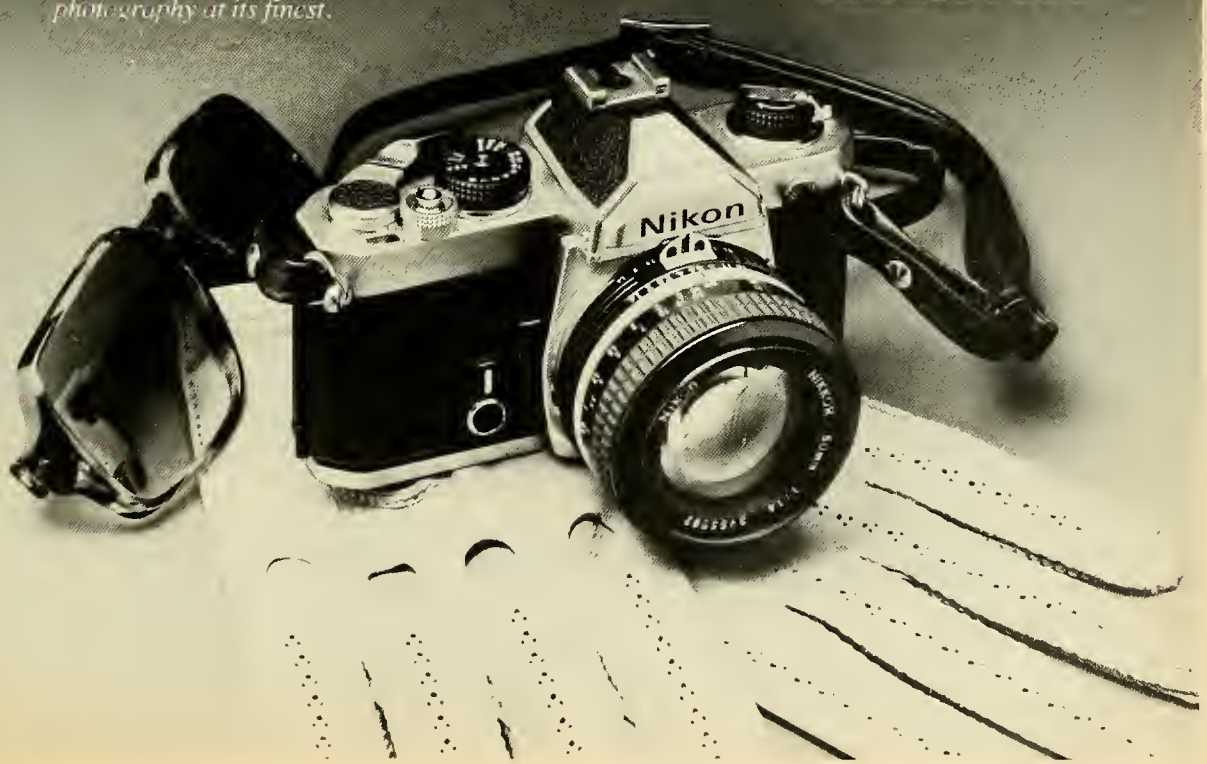
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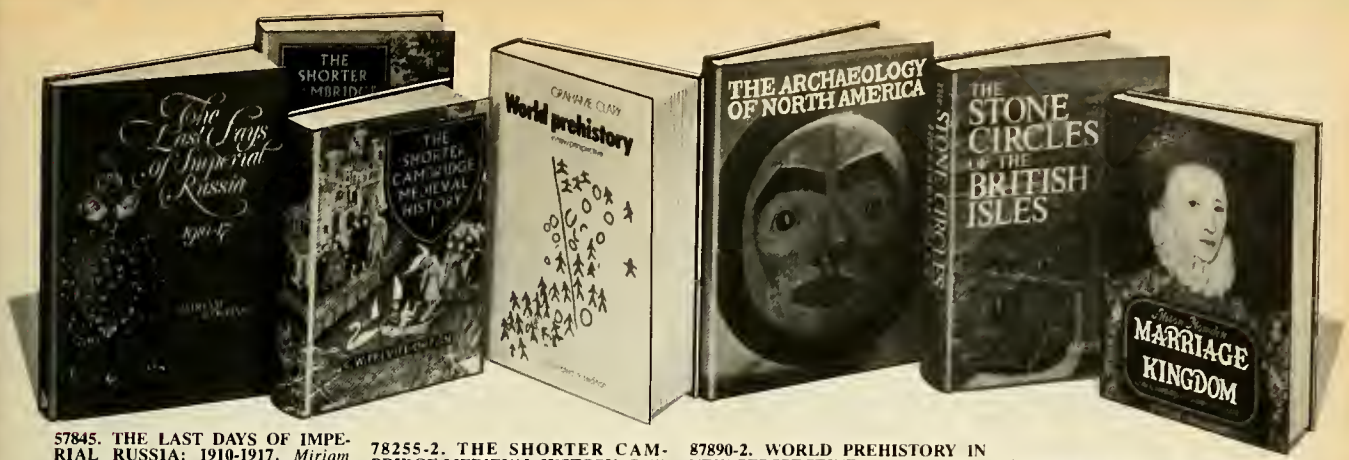
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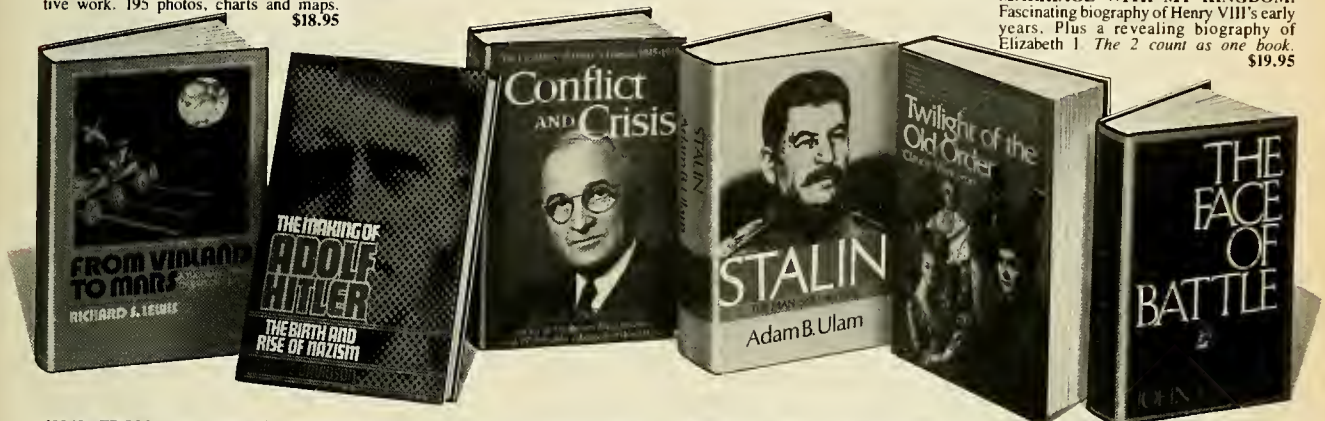
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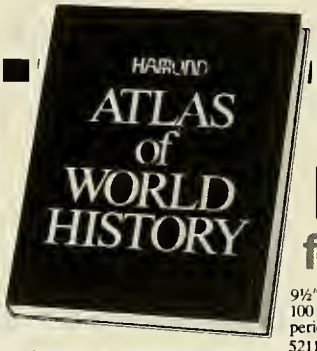
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by Raymond Sokolov

Montezuma's Bequest

Spanish conquistadors found the Aztecs drinking chocolate

Yes. It took four men, all four a-blaze with gorgeous decoration, and the chief of them unable to exist with fewer than two gold watches in his pocket, emulative of the noble and chaste fashion set by Monseigneur, to conduct the happy chocolate to Monseigneur's lips. One lacquey carried the chocolate pot into the sacred presence; a second, milled and frothed the chocolate with the little instrument he bore for that function; a third, presented the favoured napkin; a fourth (he of the two gold watches), poured the chocolate out. It was impossible for Monseigneur to dispense with one of these attendants on the chocolate and hold his high place under the admiring Heavens. Deep would have been the blot upon his escutcheon if his chocolate had been ignobly waited upon by only three men; he must have died of two.

Charles Dickens, *A Tale of Two Cities*, Chapter VII

In the twenty years since I first read that luxurious description of an eighteenth-century French chocolate ritual, it has stuck in my mind as a prime example of how, in modern times, privileges and experiences once open only to aristocrats and millionaires have spread and turned into commonplace enjoyments for ordinary people. Chocolate today is no longer a special food. The poorest urchins gobble it unceremoniously in candy bars and junk pastries. It snaps, crackles, and pops in breakfast cereals. Perhaps the last time any civilized human being thought of chocolate as a rare commodity was in Europe during World War II, when American GIs won the hearts and minds of French children by passing out Hershey bars. Hitler had not been able to change the fact that chocolate came only from tropical countries not under Nazi domination.

Now produced almost anywhere in the world with a mean annual temperature of 80° F, chocolate was originally "discovered" by the Spanish conquistadors in Mexico. Montezuma's household reportedly went through 2,000 jars a day. It spread quickly to Europe, in the form the Aztecs used, as a beverage. "Chocolate" is a corruption of the Nahuatl word *chocolatl* (a combination of the Aztec root for chocolate and the word for water). It took a while longer for solid chocolate confections to work their way into the Western menu. In any case, chocolate consumption seems to have developed somewhat later in England than on the Continent. The first reference to beverage chocolate in the *Oxford English Dictionary* dates to 1604. Despite his immense working vocabulary, Shakespeare did not mention chocolate at all. Pepys went to a coffeehouse in 1664 "to drink jocolatte" and found this still novel drink "very good." Confectionary chocolate does not crop up in English until 1659.

Like many foods imported to Europe at high cost from the New World, chocolate confused people. This is why we have inherited the barbaric word "cocoa," the result of an ignorant blurring of "coconut" with the generic term for the chocolate plant, which is, properly, "cacao." Cacao reflects the Nahuatl word for the seeds or beans from which we get chocolate—*cacahuatl*. Today, its vernacular descendant, cocoa, is normally applied to powdered, partly defatted chocolate and to the drink made from it. This is one time when it might make sense to put the scientific name into general use. Linnaeus chose well. *Theobroma cacao* not only pays tribute to Aztec beginnings but also the genus name, meaning "divine food," reflects chocolate's high place in everyone's estimation.

At any rate, chocolate does grow on trees. *T. cacao* is fairly short, rarely exceeding twenty-five feet, and produces clusters of small flowers both on its main branches and, strangely, on its trunk. Normally, each cluster of flowers turns into a single fruit in the form of a purplish yellow pod, 7 to 10 inches long and 3 to 4½ inches in diameter, with a hard rind marked by ten elevated longitudinal ribs. Inside the pod are five cells, each containing

Please turn to page 36

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five to twelve seeds embedded in soft, light-pink acid pulp.

The seeds are the valuable part of the plant, the source of chocolate. The Aztecs bagged them in standard quantities and used the bags as a form of currency. It takes five years before a cacao tree will fruit—five years of steady warmth, good rainfall, and shade. In the tropical areas suitable for cacao, shade is the rarest of these necessary conditions, and rows of cacao are commonly interplanted with shade plants, such as bananas and cassavas, or permanent shade trees, such as the coral tree, known fittingly as *madre del cacao*.

Once the cacao pods are ripe, they are broken open and the seeds are extracted. In the first step of processing, the seeds are allowed to ferment or "sweat" for up to twelve days. This destroys the mucilage on them, reduces their bitterness, and lets their color change to a cinnamon brown. Next, the seeds are dried and cured, after which they are roasted in rotating iron drums at 260° to 280° F. This develops the chocolate aroma, converts natural starch to dextrin, and further reduces bitterness. Finally, the seeds are crushed and winnowed to remove the shells and germs. The result is a rich, dark sort of edible gravel called cocoa nibs.

To make chocolate from nibs, manufacturers add sugar and flavorings such as vanilla. By then, the chocolate has become a semiliquid mass, which can be molded into tablets and sold to small, greedy children who like to smear it on their hands and faces, as well as to adults who restrain their avarice only long enough to convert chocolate into a mousse.

Such chocolate is considered too rich to drink, and so hydraulic presses squeeze out some of the fat, or cocoa butter, before beverage chocolate is pulverized into cocoa.

The leftover cocoa butter is, of course, not thrown away. It is particularly valued in the pharmaceutical and cosmetic industries because it is solid at room temperature but liquid at body heat (98.6° F).

Not only the fat but also the shells of cacao seeds have a use. They can be brewed with water to make an ersatz coffee, *miserabile*, or they can be fed to cattle. The shells also contain theobromine, a bitter, white crystalline compound, which is closely related to caffeine and whose salts and derivatives are valued as diuretics.

Cooks, however, are primarily interested in less exotic byproducts of *T. cacao*, various types of commercially available chocolate, which are officially defined in this country. The cocoas, for instance, are rated according to their fat content. Breakfast cocoa has a minimum of 22 percent; regular cocoa contains between 10 and 22 percent; and low-fat cocoa is less than 10 percent fat.

Chocolate regulation is more complex. Sweet chocolate must contain at least 15 percent chocolate liquor or plain processed chocolate. Milk chocolate must have 10 percent chocolate liquor and 12 percent whole-milk solids. In some varieties, the milk-solid component can run as high as 22 percent. Sugar content ranges widely for the various types of chocolate. Semisweet chocolate is usually 40 percent sugar, by weight. Instant cocoa can contain 80 percent sugar. Furthermore, virtually all commercial chocolate has been manipulated structurally so that it will perform specific tasks more efficiently and attractively. For example, chocolate used to coat ice cream commonly has vegetable oil instead of cocoa butter worked into it.

Chocolate processing, in one way or another, dates almost from the beginning of its consumption. According to such sixteenth-century observers as Fray Bernardino de Sahagún, Aztec aristocrats mixed chocolate with honey or purple flowers. In modern Mexico, where grind-your-own-chocolate places still exist—and probably reflect antique custom—the method of manufacture also involves a simple form of admixture and processing. Diana Kennedy writes:

> The townswomen and the peasants from the countryside [of Oaxaca] buy their kilos of cacao beans, and a certain quantity of sugar and almonds to go with them, depending on what they can afford—if they are very poor, then they buy fewer cacao beans and almonds and more sugar. Each woman picks up a zinc tub, which she places under one of the several grinding machines around the store. The cacao and almonds are poured into the hopper, and very soon a satiny, tacky chocolate sauce oozes out of the spout—which has been sprinkled with sugar so that none will stick and be wasted—and falls onto the pile of sugar in the tub below. The women have brought with them two large wooden spoons to mix it all well together, and some even have brushes so that not one speck of the valuable chocolate is left sticking to the metal. Then the chocolate is carried to another machine for a second grinding—this time with the sugar—and it is at this point that you persuade someone to let you stick your finger in and try. It is then carried home and set to dry in small molds in the sun.

Mexican chocolate, even that available commercially in this country, is a wonderful blend of similar elements. I am partial to a kind flavored, in the style of Hispanic chocolate everywhere, with cinnamon. This is the oldest known flavoring for chocolate. I first learned of the cinnamon–chocolate combination reading Elizabeth David's *Spices, Salt and Aromatics in the English Kitchen*, in which she gives a recipe for a cinnamon-spiked, egg-white soufflé called "chocolate chinchilla." She also laments the triumph of vanilla over cinnamon as the principal flavoring of commercial chocolate. More recently, Miss David has wrung her distinguished hands about chocolate once again. In her new and extraordinary *English Bread and Yeast Cookery*, she laments the passing of the "crude, rather gritty chocolate" of thirty years ago. "Chocolate processing techniques have reached so fine a stage that the remembered texture has gone, and with it some of the character." To soothe the appetites of lovers of Elizabeth David and/or chocolate, I append a slightly adapted version of her recipe for chocolate rolls.

Otherwise, it seems pointless to run through the overly familiar chocolate repertoire, limited as it is almost entirely to delicious, but completely domesticated, desserts: puddings and cakes and icings; malteds, candies, and other sweets. Two exceptions come to mind. That Mexican extravaganza turkey in *mole poblano* contains one small piece of chocolate in a rich, chili-spiced sauce. Also, some versions of pumpernickel bread take their dark color from chocolate, without taking on the flavor of chocolate any more than does the Aztec turkey dish. Finally, however, lest you think I am only interested in recherché uses of chocolate, I want to make a plug for the frozen, chocolate-covered bananas sold by



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the concession at Gilbert Lake State Park, Otsego County, New York. It is a long trip for chocolate and bananas, from the tropics to the pine-lined shores of Gilbert Lake, but the marriage of those two flavors was truly made in heaven.

Petits Pain au Chocolat
(Chocolate Rolls)

½ pound (about 2¼ cups flour)
1 teaspoon salt
2 packages dry active yeast
¼ cup plus 1 tablespoon warm milk
¼ cup plus 1 tablespoon warm water
8 1-ounce squares semisweet chocolate

1. Stir together the flour and salt in a large mixing bowl.
2. Separately, stir together the yeast, warm milk, and warm water. After this mixture is well combined, stir it into the flour. After light, but thorough, mixing, this dough should have "the consistency of bread dough, so that, when the time comes to form the rolls, it is easy to handle.
3. "Leave the dough to rise in the ordinary way. . . . When the dough has doubled in volume, break it down, knead it very little, divide it in half, then in quarters, then eighths. Roll or pat each piece out on a floured board, into rectangles of a size to fit round your chocolate . . . which you place on your rectangle of dough.
4. "Fold over first the ends, then the sides, making a neat parcel of each. Press the joins together carefully and brush with milk. Leave them on a floured baking sheet to recover shape and volume . . . about 15 to 20 minutes should be sufficient."
5. Preheat oven to 400°. Bake for 15 to 20 minutes. Serve as soon as possible. If you wish, glaze the rolls as they come out of the oven with a heated mixture of equal parts of milk and sugar. The rolls can be reheated at the bottom level of a low (200° to 225°) oven. The chocolate "*must*" be just melting.

Yield: 8 rolls

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.



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Petra of the Nabataeans

by Philip C. Hammond

New excavations suggest that Nabataean builders borrowed Pompeiian styles

For years, tourists by the thousands have filed through the Siq, a narrow, twisting mountain gorge, to reach the ruins of Petra in the Jordanian desert. In this ancient Nabataean city, exquisitely detailed architectural splendors, such as the Treasury of the Pharaoh and the Palace Tomb, have been cut out of the sandstone cliffs. But these remains have provided visitors with only half a picture of the complexity of Petra. While previous excavations had cleared tombs and graves, the dwellings, and hence the life styles of the people, were left to the imagination. Excavations over the past four years, however, have replaced theory with substance.

Petra, the capital city of the Nabataeans, has long been a choice archeological site. The earliest history of the area ties it to the biblical Edomites and the execution of 10,000 of them by King Amaziah of Judah. Centuries later, the region was populated by the Nabataeans, originally sea pirates, then land brigands and desert nomads, and later, traders, who by the first century B.C. controlled the territory from the northern tip of the Red Sea to the northern tip of the Dead Sea. They also controlled the caravan routes to China, India, Syria, and Egypt. By the beginning of the Christian Era the influence and power of the Nabataeans under Aretas IV (9 B.C.–A.D. 40) surpassed that of all other people in the area.

Even after the Romans had subjugated the surrounding regions, the Nabataeans, while nominally under Rome's control, avoided their intervention and taxes for almost a century and a half. But in A.D. 106 the Roman emperor Trajan managed to cross the Transjordanian desert and enter Petra. The conquest broke the Nabataean trade empire and, with it, the Nabataean spirit. Although the Byzantines restored a tomb for Christian worship, and the Crusaders later built a fortress outside the city's entrance, Petra's importance ended and all mention of it in historical records ceased.

Not until the nineteenth century did interest in the city revive, this time due to explorers, adventurers, and later, to archeologists, rather than to conquerors. As word of Petra's glories reached beyond the barren land surrounding it, visitors began coming to the site to view the monuments left by the Nabataeans. In 1929, the first serious archeological expedition began excavating the site. Almost a half-century later the excavations continue—a tribute to Petra's complexity and past importance.

Virtually all excavations to date have concentrated on the discovery and cataloging of structures and artifacts. The study we began four



The Palace Tomb group, at right in the far hillside, looks out over the valley that cradles Petra, capital of Nabataea.



Paolo Koch, Photo Researchers



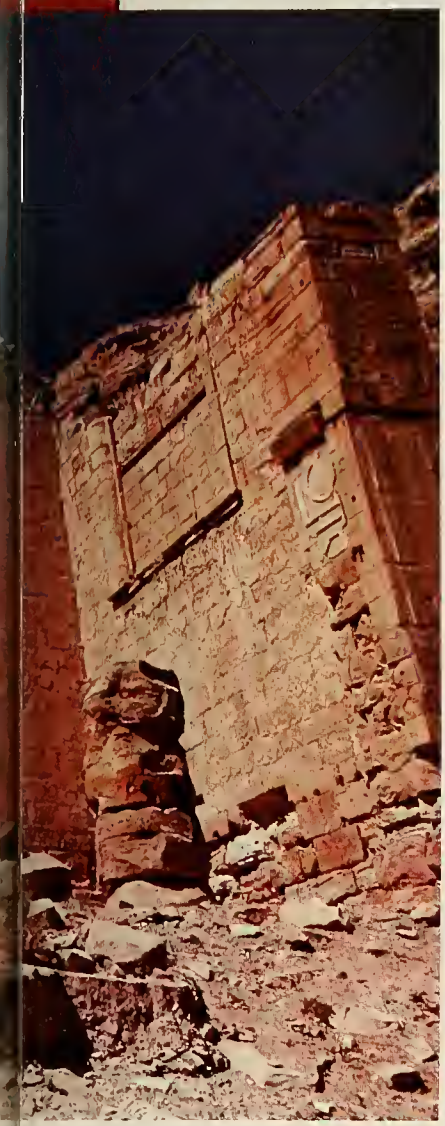
Decorated with inlaid marble and hard, painted plaster, the Qasr Bint Far'un (Castle of the Daughter of the Pharaoh) was a Nabataean temple for the worship of Dhushara.

years ago, however, focused on the Nabataeans as people. Supported by the University of Utah and the Jordanian government, and backed by funding from a Saudi Arabian businessman, excavations began at two sites chosen as a result of the first electronically instrumented survey of the area. The first site revealed a series of domestic structures dating from the first to the mid-eighth century A.D.—the peak period of Nabataean and Late Roman occupation at Petra. The second site concealed a huge religious building of skillful design and architecture that dated to the days of the major Nabataean kings. Conveniently for archeological analysis, two earthquakes had long ago sealed the remains under tons of rubble and silt.

Now, four years later, the history of the first area has been reduced to 919 "levels"—the depositional evidence of the successive stages of its use (and disuse); its buildings, rebuildings, destructions, change of function, decoration, and redecoration; and all the events that took place through time. Tied to these levels are artifacts representing the archeologists' accidental recovery of items made or used by the inhabitants.

The description of each level and every artifact has been cataloged. But this is only the beginning of modern archeological processing, for the *meaning* of these data must be sought. Why was an item there? What was it used for? Why did a wall buckle and fall? Where did a particular artifact come from? What was the purpose of enclosed space? In short, everyday life must be reconstructed from all of the data so that the *processes* of occupation can be understood.

The presence of their pottery fragments at the lowest building levels indicates that the Nabataeans were the first to occupy the towering sides and bed of the wadi, even though the biblical Edomites had lived earlier on top of one of the mountains ringing Petra's valley. The chronological position of the recovered pottery and the architectural skill evident in the design of the earliest buildings suggest that the Nabataeans settled along the wadi bed quite some time after having first entered the area. The



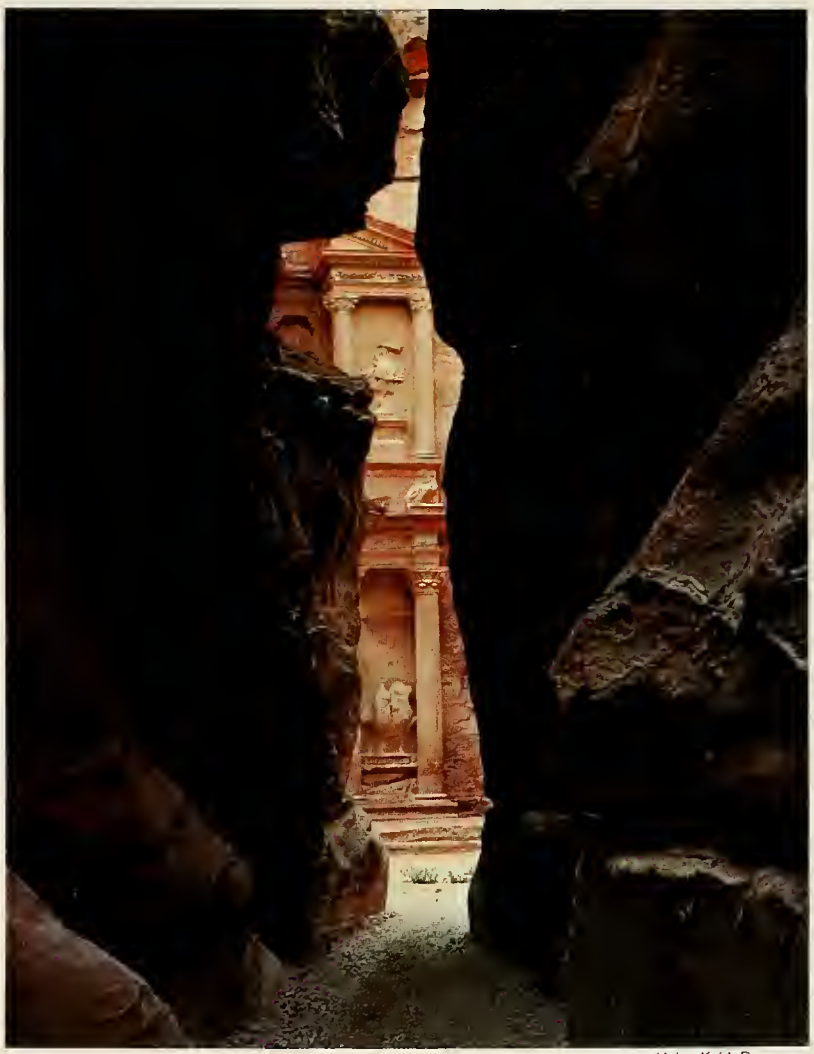
Gail Rubin

urban center of Petra itself was probably settled at the end of the first century B.C. or early in the next century.

A number of rebuildings, modifications, and other manipulations of enclosed space tell us that one domestic building complex was used for a long period, changing from time to time to fit family needs and finances. Like most homes of the Middle East today, this early complex was probably surrounded by a fence wall. Inside the wall, at least part of the area was left open to the sky as a work area with a large hearth. As further evidence of this, excavators found a large grinding mortar propped against the stairway leading up to the house. The floor of the courtyard was of clay, as were the interior floors of the house. Adjacent to the court, but within the house proper, was a pantry, set off by a clay-lined closet. The house's interior walls were plastered, with some traces of paint still visible. The recovery of a dog's skeleton, crouched in a niche in the courtyard wall, may indicate that even then urban families kept dogs either as pets or for security. The dog was apparently killed by falling debris when an earthquake overtook this first dwelling.

Seemingly undaunted by disaster, another family of Petra built their home on the site, using the ruined walls of the earlier structure as the foundation for a new series of rooms. Throughout the first three centuries of the present era, the area was continuously occupied, again with changes dictated by need and living habits, until a severe earthquake struck in A.D. 350. That such continuity existed seems uninteresting until one realizes that when the armies of Trajan marched into Petra in A.D. 106—seventy years after most of the rest of the Middle East had fallen to Roman forces—a mass exodus was believed to have taken place. Some

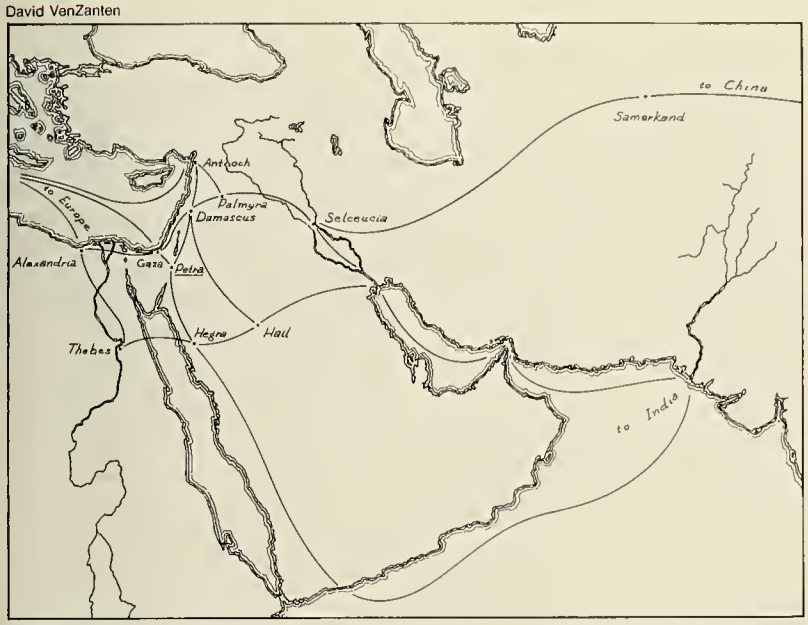
Long after the Nabataeans had disappeared, Bedouins named this red-and-peach sandstone tomb the Khasneh el-Far'un, or Treasury of the Pharaoh.



Helen Kahl, Doremus



David VenZanten



Petra's defensibility, location, and water supply made it a major crossroads of trade from the fourth century B.C. *through the first century* A.D.

archeologists believed that Petra's decline as a trading empire had begun even earlier, but our evidence completely contradicts these theories and even suggests a high level of private economic prosperity as late as the mid-fourth century. A pre-A.D. 350 coin hoard found in 1976 also indicates that considerable solvency continued. As another indication of prosperity, archeologists discovered the remains of a wooden closet that apparently disgorged its contents of imported dinnerware on the floor when the earthquake struck. That the residents could import such luxuries is another indication that Petra had not been reduced to poverty!

After that time, however, the site was abandoned until the early eighth century, when it was used as a cemetery. A Christian church was probably built nearby. With the Islamic conquest, Petra ceased to be important; the Christian residents were probably few in number and easily converted to the new faith.

Architectural remains thus supply information regarding continued occupations and the general use of the area. The contents of the levels permit even closer glimpses of life in those times. A statuette found in 1975 suggests the housewife of the day—a woman dressed in a long robe, her long hair in a braid flowing down her back. The hearth in the courtyard was probably used in good weather. The large mortar found propped against the stairway was kept at hand for grinding grain to be made into bread. Fragments of pottery cups, bowls, plates, storage jars, cooking pots, and jugs tell us what could be expected in a well-run household of the day. Although relatively few represent luxury wares, the number and variety of vessels suggest an abundance to meet the serving, storage, and cooking needs of a fairly affluent family of that period. The location of the house itself, in the very center of the city, reaffirms this. No evidence was forthcoming to suggest that the Roman occupation of Petra led either to the mass exodus of the population or to a marked decline in their standard of living. Expansions and changes in the architecture likewise reflect the same stability.

Excavation of the cella of the Temple of the Winged Lions and the domestic site nearby suggests Petra was prosperous for at least 300 years after Roman occupation.



Philip C. Hammond

The Monumental Gate on the Colonnade Street was erected to honor the visit of a Roman emperor. Like other structures at Petra, it was first attributed to the Romans, but archeologists now believe the Nabataeans built it.

ail Rubin

Faintly hinted at, although difficult to prove, is an air of femininity in the recovered remains. Jewelry, spindle whorls, needles, grinding stones, beads, and bone-tool fragments, along with the domestic nature of ceramic materials, emphasize the lack of male presence. A single die, with an unusual order of spots, is virtually the only artifact found with a masculine connotation. In a culture in which the caravan traffic required prolonged absence of a large proportion of the male population, any "domestic" situation may well have taken on a feminine complexion.

Religion is another facet of life reflected in the material remains of the domestic site. Symbols of the worship of Dhushara, the ancient desert god of the people, and his acquired consort, Atargatis, the Syrian fertility goddess, would be expected. One would also expect signs of Christianity to turn up in levels associated with the later Byzantine period. But we encountered no Christian iconography at all, just evidence of the continuation of an indigenous cult—a miniature incense altar, a large house altar, and idols (some with glass eyes and one with copper eyes set in plaster) all reflect North Arabian cults, while other bits and pieces of cultic materials are more identifiable with the Dhushara cult than any other.

Religion is the focus of the second area being excavated, the Temple of the Winged Lions. Although two other Nabataean temples have previously been excavated—at Et-Tannur on the old King's Highway and at Wadi Ramm in the eastern desert—this temple represents the first religious structure found underground and preserved in such a manner as to provide detailed information on its architecture, development, and decoration.

Excavation of the building began in 1974 and its nature was identified by the end of that season. Each season has brought architectural surprises and individual finds that have confirmed the building's importance. The discoveries have added to the clarification of another aspect of the formal religious life of the Nabataeans.

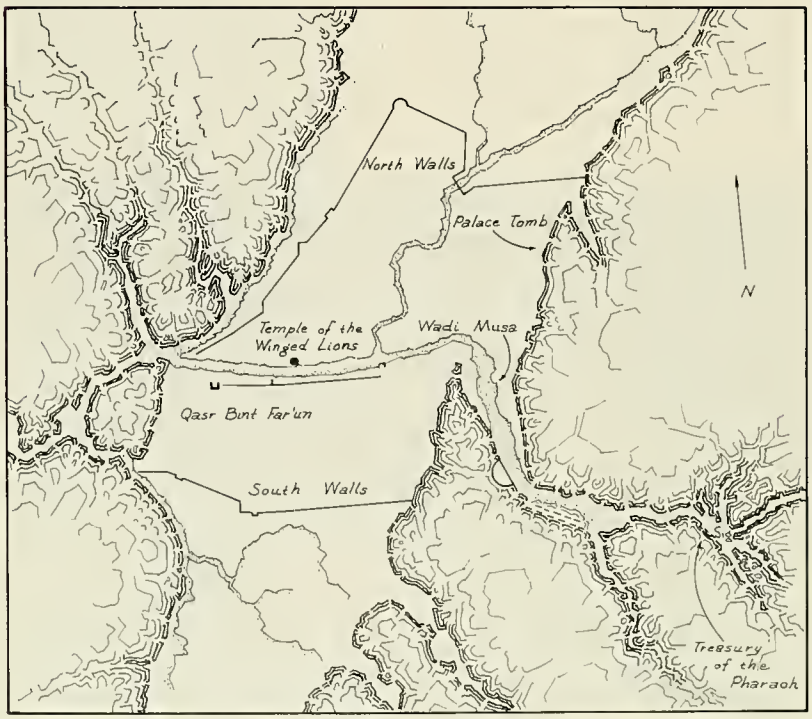
Even in 1974 the cultic nature of the structure became clear as fragments of "winged lions" (ranging from ferocious-looking beasts to pussycat types) came to light and gave it its popular name. The floor plan was obvious, even though only a part of the structure had been uncovered. Two lines of columns ingeniously meshed, with semi-engaged columns flanking niches along the walls, divided the structure into a vast hall with bays on each side and a built-up area in the center.

By the end of the 1975 season, we had further determined that this area was an altar platform approached by a stairway facing the wide front entrance. Paved floors and marble-faced lower walls were evidence of the richness of construction. But their opulence fades into relative insignificance before the splendid plaster decoration of the building, as evidenced by thousands of fragments of moldings, frescoes, affixes, and other decorative elements. On every side, color abounded from ceiling to floor.

All of the side niches excavated in 1975 had been destroyed, so little sense could be made of the nature of the fresco panels. An "eye-idol," with its Nabataean inscription almost complete, had toppled in front of one such niche, however. The inscription at its base proclaimed that it had been placed in the temple in honor of "the goddess of Hyn the son of Nybth." By the first century A.D., Atargatis, the consort of Dhushara, was the outstanding female deity, as the late Nelson Glueck had proved at Et-Tannur. Hence, this temple—obliquely across the wadi from the temple of Dhushara (known today as the Qasr Bint Far'un)—could probably be assigned to her.

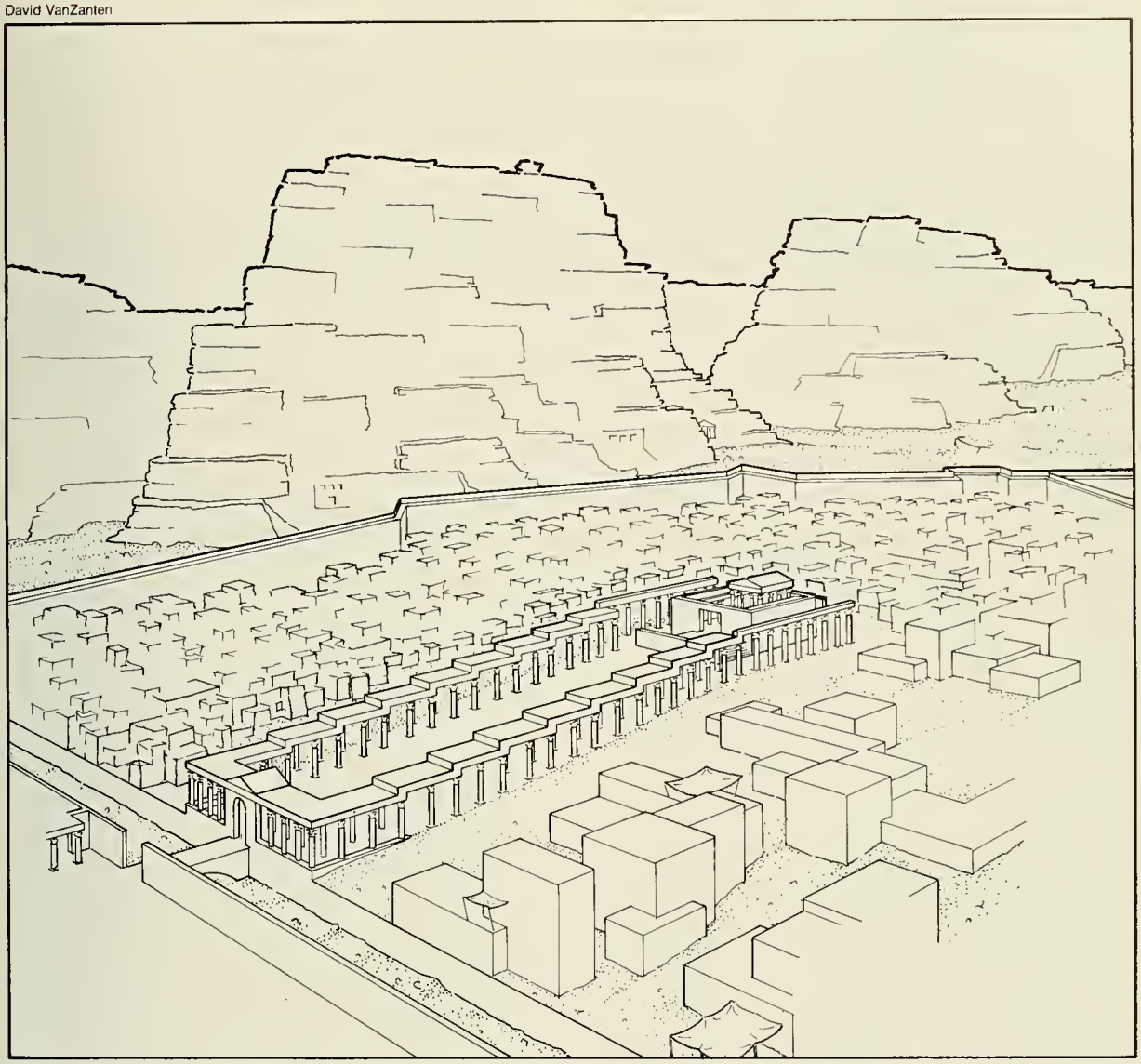
In 1976, excavations on the southwest side of the temple were completed. Because of the direction in which the temple wall had fallen, partially preserved wall niches and traces of the frescoes remained *in situ* or in larger slabs on the floor. One of the finds was a portrait bust of a male, too faint to discern features, but giving an idea

The center of Petra was flanked by 350-foot-high sandstone cliffs and further protected by stone walls to the north and south.



David VanZanten after Iain Browning, *Petra*, Noyes Press

David VanZanten



The Temple of the Winged Lions may have been approached by a double colonnade and surrounded by simple homes little different from those of present times.

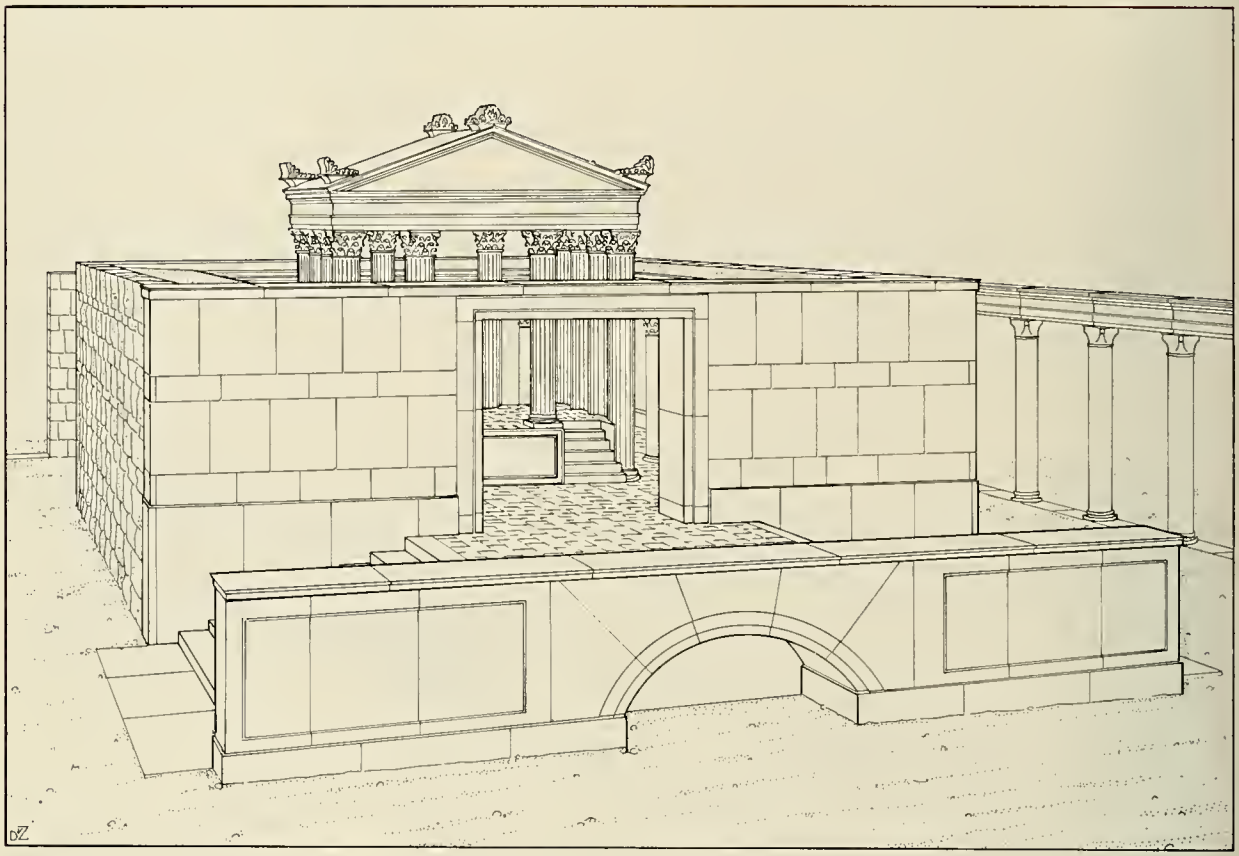
of the commemorative type involved. From sections of the western wall, we assembled fragments showing figures clad in Greco-Roman dress very similar to that seen in the ritual scenes discovered at Pompeii.

The rear side of the altar platform produced a closet with stone slab shelves at one end, probably for the storage of ritual paraphernalia. Unfortunately, the closet had been cleared out sometime after the destruction of the temple. Rust stains at the front and a slot for an iron gate suggest that access to the platform was barred.

At the end of that season another discovery further strengthened the attribution of the temple to Atargatis. In the main doorway area, we uncovered a carnelian ring-seal, perfectly preserved down to scratches on its sides from the prongs that once held it. Engraved on the seal was a nude goddess, wearing a *polis* crown (one representing the wall of a city, usually showing the front gate) and riding a dolphin—the same figure has been found at both Et-Tannur and at Wadi Ramm.

With the entire interior of the temple exposed, the 1977 season might have been somewhat anticlimactic, but such was not the case. A surface survey in 1976 had strongly indicated that the temple had a monumental entrance, rising from the valley floor some 450 feet below to the top of the temple site hill. Small stretches of wall, fragments of fallen stone, and occasional level stretches along the way all suggested such an entry. In 1977, we began uncovering the exterior of the structure. Parallel lines of walls

David VanZanten



Named for fragments of carved stone lions found on column capitals, the Temple of the Winged Lions appears to have been decorated with multicolored, intricately patterned plaster.

flanked both sides of the building, with their floors carried by massive arches. Flat, porchlike spaces appeared along the structure's front, with tremendous piles of fallen debris, including an entire column of more than a yard and a half in diameter. A marble-faced stairway, presumably leading to a landing at the level of the temple, ran along the outside of the western exterior wall. Entrance to the front of the building, 450 feet from the bottom of the hill, was probably gained by this stairway, which was carried on a series of side arches.

Holes in the front building blocks of the temple show that slabs of marble veneer had once faced it. Column drums, capital fragments, decorative carvings, and other architectural fragments strewn along the hill attest to the spectacle this building must have presented as worshipers made their way upward to its huge doors.

In addition to cultic artifacts, we recovered a mass of data from this structure, showing how the building was put together. Hundreds of pounds of plaster fragments pointed to mass production of moldings and other elements, which were then affixed to stone by dozens of iron spikes and tiny copper tacks. Holes through the centers of column drums indicated how these massive stones were raised into place; different cements and plasters showed technical skills to fit different building needs; fragments of ceiling plaster, bearing the marks of cord-wrapped reeds, indicated interior finishing techniques; fragments of wood suggested methods of roofing; saw marks and engraved lines on stone fragments illustrated cutting and finishing methods; Nabataean letters carved on stone blocks were used as a key for the transferral of the architect's plans to the actual building operation; and intriguing bonding devices showed a knowledge of stress.

Information about Nabataean technology peaked in 1977 with the discovery, in one of the rooms formed by the side arches, of a complete painter's workshop—with raw pigments ready to be ground, plaster-strengthening material, and mixed plasters in red, green, blue, black, and white left in the bottom of pots. Some forty vessels were in the workshop cache, as well as mixing pots, funnels, and sieves.

The technology, the type and

Bedouins have long believed that the urn atop the central kiosk of Khasneh el-Far'un contained the Pharaoh's treasure.

Gail Rubin



manner of decoration, and the specifics of building were generally known throughout the Hellenized Roman world of the first century A.D., but certain decorative details seem too specific to be accidental. Inscriptions attest that the far-flung commercial interests of the Nabataeans had reached Roman Italy by the end of the first century B.C., and perhaps the commercial centers of Pompeii and Herculaneum were on the trade route as well. A lavishly painted tomb at El-Barid, adjacent to Petra, has been classified as Pompeiian and the decorative motifs of the temple reflect a similar influence. Yet another Pompeiian-style plaster, painted to look like marble, shows up here, as does a preference for the colors in wall-fresco decoration found in later periods at Pompeii, along with very suggestive ritual scenes. Thus, direct or mediated influence may well be involved since Pompeii was at its height at about the same time that the Nabataean king Aretas IV was expanding his building operations throughout Petra. We have attributed the construction of the Temple of Winged Lions to that monarch on the basis of stratigraphy, numismatic and epigraphic evidence, pottery, and the economic situation.

The discoveries made at the temple complex reflect to a large extent the prosperity of the Nabataean empire. Good fortune continued after the reign of Aretas IV, but excavations have uncovered evidence that power was diminishing. Sometime during the reign of Aretas's successor, Malichus I (A.D. 40 to 70), the temple was refurbished with freshly plastered and painted columns and restored frescoes. But during this time, Rome was beginning to tighten the net around the Nabataean kingdom. That may be why the fresco panels were painted in only one color, unlike earlier frescoes with "foreign" motifs.

Excavations showed that at a later period the roof of the temple burned and fell in. Although there apparently was no major damage, no attempt was made to rebuild the roof, suggesting a low period in the site's history. This situation fits into the final years of Rabbel II (A.D. 70 to 106) when Roman constriction of trade routes must have affected the Nabataean economy, causing the king to desert his capital and take up residence at Bosra in Syria. Respect for the sanctity of the temple site is obvious, but also obvious is apathy in restoring such a lavish structure.

The earthquake of A.D. 350 was the final blow to the temple. Many of Petra's buildings crumbled and were never restored. Another earthquake in the mid-sixth century leveled the remaining structures. Fortunately for us, these catastrophes preserved many artifacts and signs of the area's former use under the tons of rubble.

Taken together, the two areas of excavation reflect both economics and natural disaster acting upon a population. At the same time, they provide other information—the eclecticism of Nabataean culture, the tremendous engineering and architectural skills, and the impact of the kingdom's main occupation, international trade, upon the life of the capital city.

Such internationalism could hardly have been expected from a band of nomadic wanderers, as the Nabataeans appear to have been in the earliest historical accounts we have of them. But the occupation of Petra, the expansion of caravans, and the ability of these people to adapt to new technology and commercial possibilities forged them into a political and social body of major importance in Middle Eastern history. Recent knowledge of Chinese trade routes suggests that, along with the luxury products of Arabia (especially frankincense and myrrh), Egypt, Persia, and India (whose trade routes were linked to those of the Nabataeans), the wealth of ancient Cathay may also have moved westward, carried by Nabataea's caravan princes—middlemen of the ancient world. □



This Zeus-like figure found at Et-Tannur, a site near Petra, resembles the heads of kings on Nabataean coins.

George Holton, Photo Researchers



Terns in Traffic

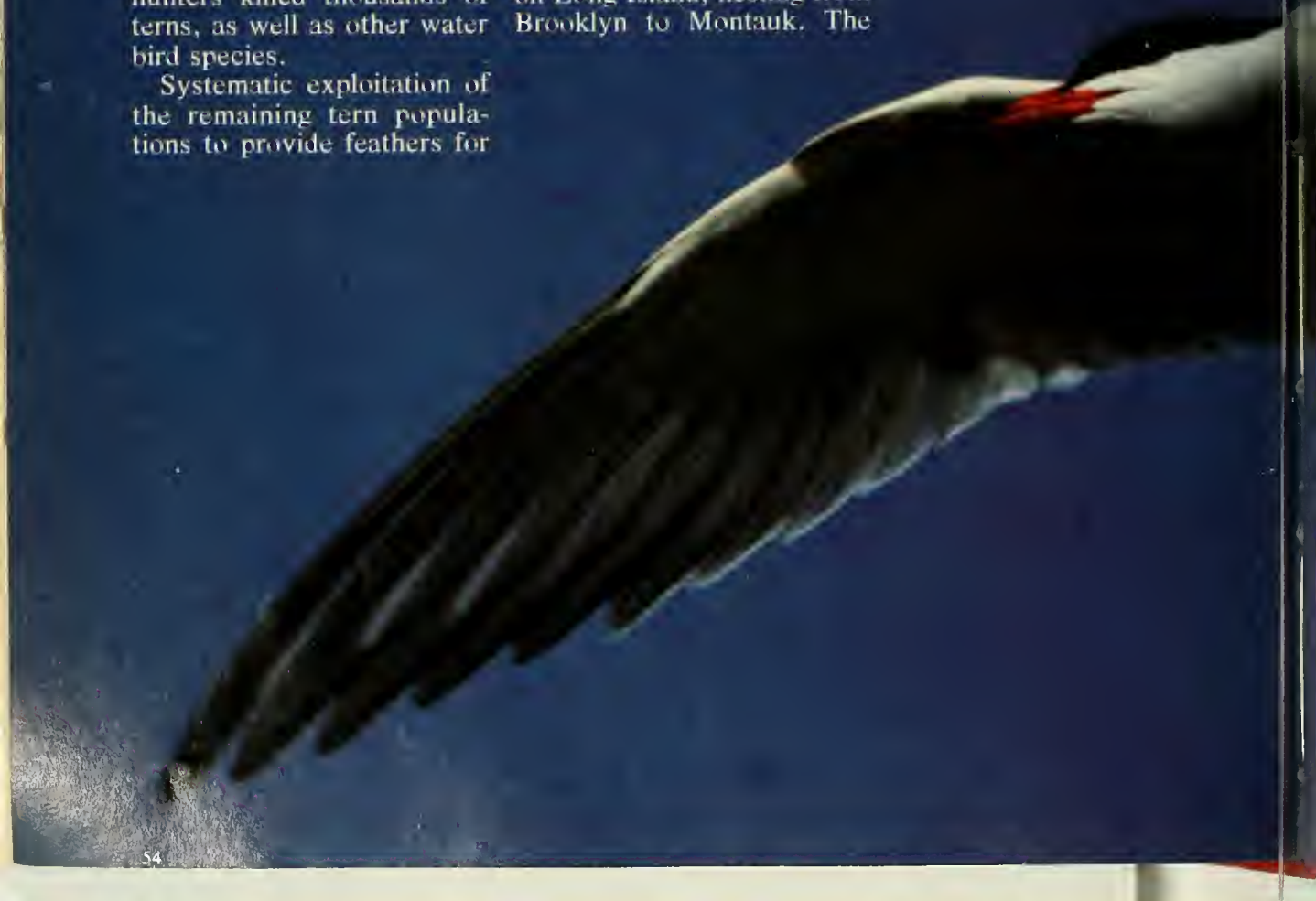
by Michael Gochfeld

Sea birds can nest near people, if they are not harassed, stomped, or run over by cars

Until the middle of the nineteenth century, common terns were abundant on Long Island, nesting each spring and summer on beaches, in grassy swales between dunes, on rocky bars, and on smaller offshore islands. But as New York City grew and expanded to Long Island, the stability of these large bird populations came to an end. Egging parties ravaged nesting sites, and market gunners and sports hunters killed thousands of terns, as well as other water bird species.

Systematic exploitation of the remaining tern populations to provide feathers for the Parisian millinery trade nearly gave the *coup de grâce* to the species. From 1880 to about 1920, the shrieking cries of terns were rarely heard on Long Island. The strict conservation law of 1913 came none too soon. The species had survived commercial exploitation on only a few remote islands, such as Gardiners Island off the eastern tip of Long Island. Such isolated colonies provided stock from which the rest of Long Island, and much of the Atlantic coast, was repopulated.

The recovery was gradual, but by the late 1950s the species was again widespread on Long Island, nesting from Brooklyn to Montauk. The revival was not to last, however. Once again, man was responsible for the bird's decline, as the postwar boom in housing gobbled up suitable nesting areas. Although Long Island's reduced tern populations are now more-or-less stable, the species still knows little peace. The weekend flotilla of pleasure and fishing boats in Great South Bay, for example, is a phenomenon that no breeding tern population can escape, except by leaving the area. Picnickers equipped with Frisbees, dogs,



photographs by Allen Rokach

baseballs, and even motorcycles occupy every island and sand bar.

Nevertheless, some nesting habitat still remains on Long Island—on sandy areas amid beach grass and seaside goldenrod, on spoil banks, and in salt marshes. But if the birds are to breed on solid ground, they must do so in protected places, such as the American Museum of Natural History's Great Gull Island and parts of Jones Beach State Park.

I have conducted my research at two large colonies: at West End Beach in Jones Beach State Park and at Cedar Beach, twelve miles to the



Common terns are excellent, almost tireless, fliers and spend many hours of the day aloft. They skim the ocean waves, often snatching small fish on the wing.

east. Both areas are less than thirty miles from New York City. In recent years, each colony has had more than 2,000 pairs of nesting common terns (*Sterna hirundo*). The older colony, at West End Beach, is adjacent to a large public parking lot. On weekends and warm summer days, thousands of cars—carrying as many as 10,000 beachgoers—use the access road that curves through the colony. I have long been intrigued by the coexistence of birds and beachgoers, for one cannot help wondering how any wildlife could thrive amidst such bustling human activity.

Common terns have one nesting peculiarity in their favor. They avoid unvegetated outer beaches (the areas most frequented by sunbathers and swimmers) in favor of patches of beach grass and goldenrod. The least tern (*Sterna albifrons*), a smaller species that prefers open, sandy beaches, is now considered threatened in the east, and the Pacific coast race is endangered—its numbers diminished by human recreational activities within its colonies and, perhaps, by pesticides as well.

Human beachgoers also have strong preferences. They crowd together close to restaurants, restrooms, and other facilities. Seen from the air, the dispersion of humans near the parking lot on West End Beach produces a bell-shaped curve characteristic of a "normally distributed" population. Only a few people frequent the dunes and beaches away from the parking lot and facilities, thus leaving the bird colony relatively free of human intruders. The main contact between birds and people is the almost constant stream of automobile traffic on the road through the colony. On any summer day, however, instances of human intrusion into the colony do occur, and it is important to examine how birds and intruders react to each other.

Common terns usually produce a clutch of three well-camouflaged brown and speckled eggs. The nest itself is a simple indentation in the ground, embellished during the incubation period with straw or bits of

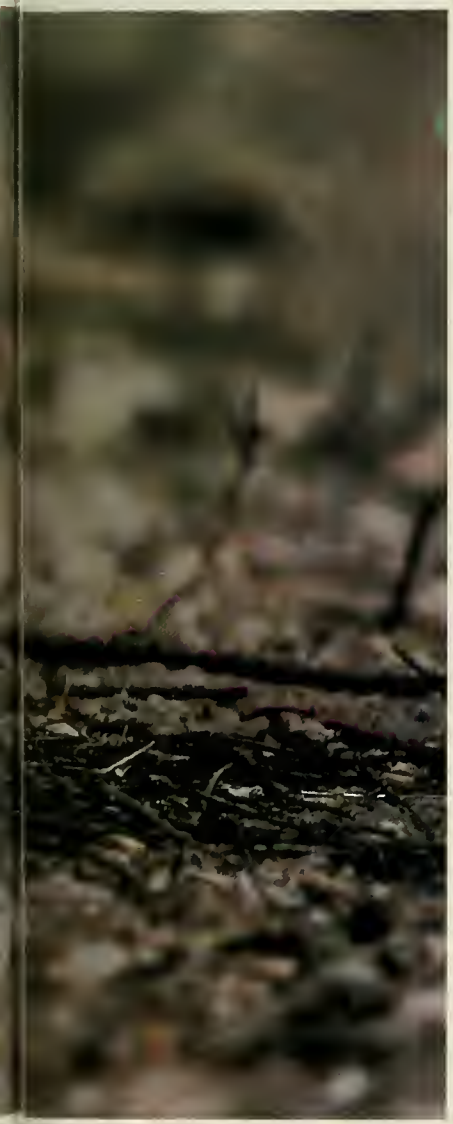


shell. An uninitiated human intruder or natural predator cannot easily see the eggs. Once one knows what to look for, however, hundreds of nests can be found in a short time.

On rare occasions, people come to such colonies to collect eggs for food in the tradition of some European and South American cultures. Although such activities are strictly illegal, they do take place and can entirely eliminate a breeding population of birds. Fortunately the West End Beach colony, despite its accessibility, has not been subject to egging. Vandalism, however, does occur. Footsteps are often seen leading into the colony and ending at a nest containing a broken egg. Perhaps this is due to a misplaced foot or to simple curiosity—a desire to see what is inside an egg. But sometimes, the footsteps lead to a pile of wantonly broken eggs.

Much rarer is the vandal who deliberately kills the chicks. Some vandals have been known to enter a colony and shoot or stone the adult birds; in one case a person drove a beach buggy through a colony in an apparent attempt to demolish nests. The colony at Breezy Point in Brooklyn was destroyed by vandals in 1972 when it contained 2,000 pairs of common terns. A bird bander who periodically checked on the fortunes of that colony arrived one day to find the beach grass ablaze. Two adolescents told him

The typical nest of the common tern is only a scrape in the ground lined with plant and wood debris. But the birds are adaptable nesters, and on Great Gull Island in Long Island Sound, a colony nests among the traprocks of the shoreline. Because they avoid open, sandy beaches, the birds are less harassed by people than some other tern species. On a nest at West End Beach in Jones Beach State Park, left, a chick peeks out from under a sheltering parent. In the two pictures below, one bird brings a fish to its mate, then takes a turn on the nest. Both sexes incubate the eggs, brood the young, and bring each other food.









that they had set the fire to see what the birds would do. As might be expected, the birds left. They joined the more secure colonies at West End and Cedar beaches.

By nesting near a heavily used public area, the West End Beach terns may gain some protection from such destruction. Not only are the birds more or less in the public eye, but the area is regularly patrolled by police who chase intruders out of the colony. During my work there, I have frequently been hailed by irate passers-by wanting to know why I am disturbing the birds. Such public interest, always encouraging and occasionally sobering to the field biologist, also affords protection to the terns. In addition, the State Park Commission has placed signs outside the nesting area warning would-be trespassers to keep out.

Nevertheless, there is still interference—by fishermen taking a shortcut to the bay and by curious visitors and photographers, not to mention biologists. Such disturbances entail some risk of direct damage to eggs or young, but their principal harm is that they keep adult birds away from their nests.

The terns are not entirely helpless, however. In places where they are accustomed to human intrusion, the birds lose their fear and do not hesitate to attack. They generally begin their defense when they sight someone approaching the colony. Usually a single bird or small group sounds the alarm, flying directly toward the intruder and uttering a particularly harsh, guttural call. At West End Beach, the entire colony of up to 5,000 common terns and 300 black skimmers normally reacts to an intruder by rising in a swirling, screaming mass. The effect is startling and tends to turn away the uninitiated.

Landing at its nest, a common tern prepares to settle down and incubate the clutch of speckled eggs. Cats, rats, gulls, and other predators take a toll of unguarded eggs and young.

Within thirty seconds most of the terns will have resettled on their nests. Subsequent disturbances during the day produce only local reactions—50 to 200 terns circling overhead and darting downward at the intruder while uttering the attack calls. Frequently, the birds discharge their foul-smelling, semiliquid cloacal contents with remarkable accuracy. This proves aesthetically displeasing to most people, but it apparently does not deter natural predators.

A few terns—more aggressive than the rest—may actually strike an intruder. These birds usually fly a steep, U-shaped path, diving for the head, pecking it vigorously, and rising up again to repeat the attack. An individual bird will strike repeatedly every 2.7 to 3.2 seconds for a minute or two. When several birds are involved, a person could receive twenty to sixty blows a minute. The ferocity and frequency of attacks mount during the incubation period, peaking when the eggs are hatching. On one June day, I estimated that I was struck more than 10,000 times; on most days in June, several thousand strikes is a typical reward for studying terns.

The force of a tern's strike can draw blood, and protective headgear is essential. A soft hat with an object on the top may divert the birds' attention. During my fieldwork, I have worn pith helmets, but the birds poked holes through them after only three weeks of wear. I now use a plastic hard hat whose surface is heavily scarred and chipped from the numerous pecks it has received. Such aggressive defense must be viewed as a compromise between opposing selective forces, for on rare occasions a bird can injure itself by striking too hard. The greater risk of such aggression, however, is that a bird's eggs and chicks are unprotected when it joins an attack, and its nest may be subjected to predation or exposure. John Emlen, one of the progenitors of the study of behavioral ecology, has termed such behavior "aggressive neglect."

The effectiveness of the tern's aggressive defense is difficult to measure, but one definite result is that it prevents many people from entering large colonies such as those at West End and Cedar beaches. Most individuals beat a hasty retreat as soon as the terns begin their attack. In smaller colonies, the aggression is less intense, the umbrella of diving and screaming terns is less cohesive, and the deterrent effect is much diminished.

The terns are also quick to mob such avian intruders as gulls and hawks that fly over a colony's air space, particularly if they are lower than seventy-five feet. Relatively few gulls, however, prey on tern eggs or chicks, at least in the two colonies I have studied. A Finnish biologist, Risto Lemmetyinen, has found that crows frequently attempt to prey upon young terns but are harshly attacked and driven off by the aggressive adults.

Although hawks and owls patrol the barrier beach at Jones Beach from time to time, they are rare during the summer. Foxes, raccoons, opossums, skunks, and weasels, all potential predators, have been observed on the beaches in recent years. Rabbits are the only undomesticated species that passes through the nesting area with any frequency. The terns retaliate by vigorously mobbing the inoffensive animals, which dash frantically back and forth in an effort to avoid strikes. Yet, when dogs wander into the colony, the terns will mill about overhead, calling loudly but not attacking. Dogs can severely damage a tern colony, particularly once the chicks have hatched. Cats and rats also take a toll of both eggs and chicks.

Other bird species take advantage of the terns' aggressiveness, which can be taken as a sign of its effectiveness. Black skimmers, for example, regularly nest in tern colonies, as do several duck species—mallards, old squaws, and tufted ducks. Apparently the nesting success of these species is enhanced by proximity to the terns.

In most tern colonies the heaviest losses occur when the chicks are only a few days old and vulnerable to predators. But owing to the lack of predators in the West End colony, the chicks pass through this



An aroused tern swoops down to attack an intruder in the nesting area. The birds will dive at a person's head and peck with vigor. Such attacks are most frequent during the incubation period.



stage with a high rate of success. Tragedies abound a month later, however, when the chicks are learning to fly and crowd the access road to the beach's parking lot. Ordinarily, terns at this stage of development frequent open beaches and exercise their wings while their parents fish in the ocean beyond. At West End Beach, the smooth road serves as a substitute runway; during July and August hundreds of chicks rest on it and jump and flap along it to improve their flight capabilities. The learning process often ends suddenly and fatally as cars traveling to and from the beach unavoidably run over the birds. On a single day, there may be twenty or thirty squashed birds on the road and others with broken wings standing helplessly on its edges. In one season, 1,400 fledglings, more than 50 percent of the young, were killed in this manner.

Paradoxically, fewer young birds are killed when the traffic is greatest. During these times—humid weekends in July—the constant

stream of cars crowds the birds off the road and the death toll is minimal. The mortality rate could be reduced by erecting drift fences along the road or placing bumps on it to slow traffic. Park officials are sympathetic to the perpetuation of the colony, and we hope they will institute such measures.

When terns are repeatedly thwarted in their attempts to raise young, they move to another site. The failure of the West End Beach colony to grow appreciably in recent years may be due in part to the high numbers of fledglings killed. Some adults may have given up on the site and moved elsewhere.

Although the tern populations on Long Island have remained stable in recent years, the dearth of suitable nesting habitat implies that the birds cannot tolerate too much more disruption before they begin to decline. The terns in disrupted colonies have been forced to nest in marginal habitat such as salt marshes. Terns have long nested in salt marshes in both Europe and North America, but until a few years ago researchers did not realize that at least one-third of Long Island's terns used this habitat, which is still abundant along the island's shores and is relatively free from disturbance by humans.

These birds make their nests on sea wrack—flat mats of dead cord grass. In some places, they lay their eggs on the partially flattened stems of salt marsh hay. This habitat, however, is a poor alternative to the more traditional beach colony sites. Tides frequently flood the mats of dead vegetation, which may break apart and drift away. Almost every salt marsh colony I have visited shows signs of significant flood damage. When disturbed, chicks may run off the edge of the mat, fall into the mud or water, and perish. In a few cases where the mats are on higher islands, rats thrive and make short work of eggs and young.

On Lane's Island just west of Shinnecock Inlet, Paul and Francine Buckley, on a survey for the National Park Service, found a thriving colony of common and roseate terns nesting on wrack. During subsequent annual visits to the colony, I have found abundant signs of rat damage and have observed that productivity is now essentially zero. The number of tern pairs has declined from 1,500 to only 500. Roseate terns, a species that seeks dense cover for nesting, are particularly vulnerable to rats and have been almost entirely eliminated from Lane's Island.

The future of terns on Long Island is grim if the salt marsh nesting option should become the only one available. Banding studies have documented that at least some of these birds have come from beach colonies. The productivity of marsh colonies is very close to zero, while beach colonies usually produce one to two young per nest in most years. The move to salt marshes must be viewed as an alarm sounding the poverty of more suitable habitat on Long Island, and the few remaining, protected beach colony sites must be considered vital to the perpetuation of the species, even though the birds suffer some harassment by humans and risk death by cars. □



Waving their clothes to send nesting terns into flight, a group of youngsters typifies the problem of harassment at West End Beach. Such fun and games can cause the birds to abandon their nests.

Swamp Dwellers of Bahia

by John Cordell

The introduction of modern fishing gear has altered the once stable society of northeast Brazil

The susceptibility of northeastern Brazil to natural catastrophe weighs heavily on its population, mostly peasants trapped in a semifeudal land-tenure system that is unable to absorb continuous generations of unskilled sharecroppers. To endure, many peasants must become masters at the economics of scarcity.

The government relied for years on the supposed richness of Amazonas' soil to provide a paradise for poverty-stricken peasants. Government officials predicted that the construction of the Transamazon Highway would induce peasants by the millions to flock to the rain forests, settle a new frontier, and begin a new life. But the plan did not work. Discouraged by Amazonas' thick forests and poor soil, many of the pioneers returned to their traditional homes in the northeast. The northeast, however, already had a traditional frontier of its own, a vast mangrove swamp stretching from the semiarid north coast of the state of Ceará to the southern part of the state of Bahia. In this biologically and culturally transitional world, modern Brazil ends. It is replaced by a backwash area, home to an agglomeration of swamp dwellers whose lives are bound far more to the rhythms of the tides than to a booming industrial economy.

The swamps, richly stocked with aquatic life, are owned by no one: historically, they have served as an escape hatch for the population of the northeast. Anyone who has lost out in the wider economic order is free to enter them and engage in a combination of subsistence pursuits—fishing, slash-and-burn farming on the laurel-forested swamp border, or the collecting of forest products and the hunting and trapping of exotic birds.

Many swamp fishermen spend a part of their early lives as migrant wage laborers on nearby sugar plantations. Near the coast, however, much of the agricultural wealth is in tree crops, such as rubber, which do not require intensive labor. Nowadays there is little steady wage labor, and every morning the unemployed form long lines outside the palm oil, textile, and copra factories. When all else fails and inflation cuts deep into their meager savings, these people head for the swamps.

Unlike some financially poor but culturally independent tribesmen, the marginal peasant in Brazil is always at the mercy of an encompassing financial system. Even the swamp offers no escape from this dependency. To exploit the resources of the swamp, people must still have some cash on hand for such indispensable purchases as matches and kerosene. The latter is highly regarded as an insecticide and, when mixed with seawater, as a purgative for the infestations of tropical parasites that abound in these latitudes.

Swamp-dwelling communities are characterized by roof-high shell middens, which grow up around the rudimentary palm-thatched shelters. As the fishermen shift seasonally to new gathering areas, the middens are all that remain. The rewards of swamp living are the accumulation of basic household provisions—fruits and berries; mangrove roots, which can be woven into baskets; palm fronds for sleeping mats; and mangrove bark from which a dye is extracted for fishnets. Tidal creeks provide eels, guppies, and crabs for baiting the longlines, while mud flats and shallows produce an assortment of mussels, clams, and oysters, which usually can be marketed to maintain a small cash reserve. The men cut tucuma, or palm fiber, for the draglines of their large nets, and poles for fish corrals and mangrove fences (traps that catch fish in the ebb tide). They also spend long hours gathering firewood and preparing charcoal for the cold and windy nights of the wet season.

On an unprecedented scale the coastal poor penetrated one of Brazil's most inhospitable habitats. In the city of Recife alone, more than 100,000 people inhabit a swamp slum that sprawls over the mud flats of the Capiberibe River. Long a temporary refuge in times of job and food scarcity, swamp living has become a permanent way of life. At the same time, fishing activity has centered increasingly on the resources of the swamp itself, rather than on net fishing in estuarine waters, until recently a profitable occupation that served to organize the communities. Many fishermen who used to fish the estuaries from canoes now work exclusively as crab scavengers and shellfish collectors, occupations that, in the structured Brazilian society, are considered to be among the lowliest.

In towns outside the swamps,

Luis Villota



Loren McIntyre





John Lewis Stage, The Image Bank



Maureen Bisilliat, *Editora Abril*

Swamp fishermen work with thrown nets, above left, or with nets dragged behind dugout canoes, left. Shellfish are harvested by hand in a tidal creek, above.

people make no attempt to conceal their disdain for swamp dwellers. When I was studying livelihood patterns in the swamps, I was often reminded that where the street ends, so do the people. Swamp settlements, however, are by no means homogeneous. They have better and worse neighborhoods, a class system within a class system.



Stark neighborhoods nicknamed Bolivia and Brasilia are made up almost entirely of ragged crab gatherers and shellfish collectors, whose crude lean-tos or incompletely walled mud shelters are in marked contrast to the tile-roofed stucco houses of the remaining net-fishing neighborhoods.

During my stay, a residue of the most versatile net-hauling specialists continued to fish the estuary, although less for the market than for home consumption and less with their nets than with traps and trotlines that could be operated independently with low upkeep.

Hunger and disease are rampant in the swamp communities. No sooner had I moved into a house in one of the more populated swamp districts than a woman collapsed and died at my front door. An autopsy revealed less than a thimbleful of water in her stomach. The quest for food is an endless and anxious daily improvisation; to procure the bare necessities people must be constantly on the alert. Roving bands of children forage for crabs in the swamps or beg in the town. They sleep in one place, eat in another, and find some garment of clothing in still another. Common health problems, which ordinarily could be easily taken care of, develop into long sicknesses. Among the most impoverished fishing and swamp families, the infant mortality rate ranges from 39 to 90 percent. Fishermen suffer widely from abscessed teeth and gangrenous infections that result from untreated fish bites and coral cuts. To satisfy their need for calories, children and pregnant women develop a craving for soap or laundry starch. Because illness often leads to abandonment, women-centered households are becoming the norm in many of the swamp communities I visited—a departure from the standard of the extended family of rural Brazil. A number of people, mostly men of indeterminate age, simply live alone in the swamp, oblivious of their past and seemingly indifferent to their present pitiful condition.

The scale of swamp colonization is difficult to estimate because census takers ignore these neighborhoods. Although personal registration is required by law in Brazil,



swamp settlers cannot afford the fees to renew their identity cards, and many let them lapse. A birth certificate can be obtained for five dollars from a doctor. But how many of these people know or can afford a doctor? Nor can they afford weddings or burials. The dead are usually dumped unceremoniously into the swamp.

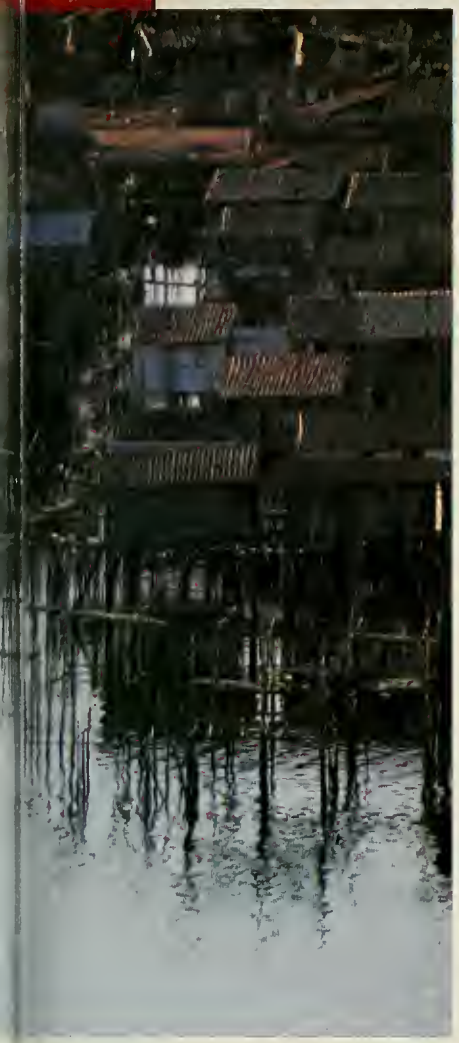
Despite this bleak picture of deculturation, swamp dwelling appears to be a fairly recent social transition. Although dislocated environmentally, fishermen remain psychologically oriented toward an earlier, more favorable life style, which was possible under the traditional system of estuarine net fishing—a system that has changed in the past eighteen years owing to the economic impact of modernization.

In 1960, fishing from rafts and canoes—the principal inshore pattern in the northeast—was catapulted into an era of speculation and technical innovation. Entrepreneurs, as hungry to open up new markets as the land-starved peasantry was to sell its labor, introduced nylon nets manufactured in Japan. According to tests conducted by the United Nations Food and Agriculture Organization, fish catches were far larger with nylon nets than with more traditional fiber nets. Nylon nets were promoted in the swamps as part of a modernization scheme to increase the supply of fish to urban markets in the northeast. Accordingly, a fishery improvement agency was established, chiefly to educate peasant fishermen in the use of modern gear and motorized vessels and to reorganize the traditional guilds into cooperatives.

The plan looked good on paper. As an incentive to increase productivity, large quantities of nylon nets were made available to private investors who could arrange attractive financing through the Banco do Brasil. These investors would also act as middlemen, selling the nets directly to fishermen or farming them out on a profit-sharing basis. To insure that the fishermen used the new equipment, the middlemen introduced nets that most closely resembled traditional beach seines (gill nets particularly adapted to stingray fishing) and mullet nets (which either encircle a school or drift with the tidal current).

The decision to promote technological innovation proved to be a costly mistake. For the fish of the local estuary—especially stocks of shrimp, flounder, and snook—the finely meshed nylon beach seines were a deadly adversary. Even in clear water, fish cannot see nylon and the 2-cm mesh traps fry as well as adult fish. When the use of nylon nets became widespread throughout the swamps, as many fish died and rotted in the tidal creeks as were caught and sent to market.

Fishermen, too, had trouble with nylon; some went blind mending the almost transparent filaments. But nylon's impact was felt most in the traditional net-fishing neigh-



Luis Villota



Luis Villota



Nilo Lima, Rapho/Photo Researchers

The Algados slum, above, which housed 20,000 people, was recently razed by the government, but many slum districts, above right, still exist in Bahia. Right, a fisherman goes to market.

borhoods since it changed the entire incentive system and flow of authority in fishing.

Swamp fishermen have approximately 135 square miles of waterway available to them at different seasons. This area is divided into an inner fishing ground of tidal creeks and rivers, and an outer ground that includes the main estuary, tidal inlets, the surf zone, and fringing reefs. Traditionally, fishing in the mangrove swamps and adjacent waters was limited not by the size of the area but by the fishermen's perceptions of time. As in other maritime cultures, time was

marked by both the recurrence of the seasons and the constancy of the tides.

During spring, for example, a six-knot tidal current sweeps up and down the estuary, strongly affecting the efficacy of the different types of nets. The same current might impede the efficiency of one type if used against the tidal flow, increase the efficiency of another, and preclude the use of a third. Fishermen classified the grounds according to the varying tides along the course of the estuary and chose their fishing spots and methods on a day-by-day basis, always allowing for the mechanical influence of daily and fortnightly tidal rhythms.

An understanding of lunar periodicity and its effect on the movements and concentration of marine organisms was also crucial to success; through such knowledge, fishermen could pinpoint the migratory patterns of the more highly valued species—white and yellow catfish, bluerunner, and gray mullet.

Mastery of lunar-tide reckoning was thus essential for successful fishing in the swamps, and apprenticeships to acquire this knowledge were judiciously controlled by captains of the fishing canoes. In the long run, possession of this knowledge was a prime factor in controlling fishing pressure. Following the lunar-tide calendar not only helped the fishermen synchronize boat movements and the choice of fishing methods according to biweekly and daily tide fluctuations, it was also an important element in conservation. The precise work routines established by fishing captains—and dictated by lunar periodicity—assured the continuing availability of estuarine stocks. To a swamp fisherman, a fishing spot is not purely geographical, but rather a temporary locale whose productivity is determined by the lunar phase. Since the tide goes through two complete cycles (spring to neap and back to spring) every twenty-eight days, each day in the cycle opens up a different set of fishing spots in the estuary. The lunar-tide calendar is a precise index of changes in fish behavior.

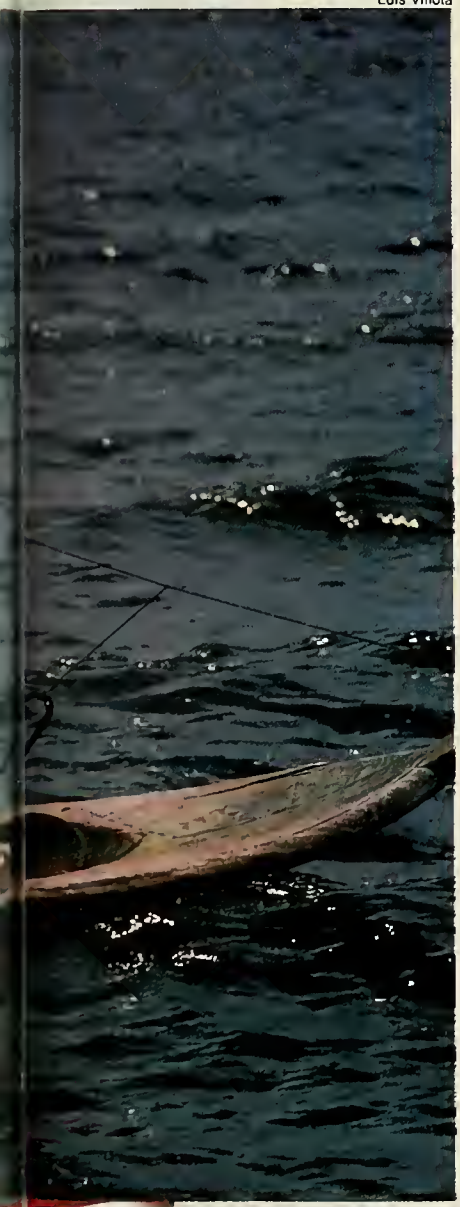
Given these natural limits to the expansion of estuary fishing, it was



not surprising to find that fishermen established definite property claims over lunar-tide fishing space, claims that firstborn sons and apprentices inherited. Because these territories always changed according to the lunar phase, charges of overexploitation by certain individuals or villages did not conform to the common-property theories ordinar-

Below, a line fisherman snags a ray. Both traditional, dark fiber nets, right, and finely meshed, blindingly white nylon nets, below right, are used to fish the rivers and estuaries.

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ily used by anthropologists to explain overexploitation in both open ocean and inshore fisheries. In the absence of a formal legal system to prevent encroachment, fishermen relied on a cooperative ethic and an

Left, a fishing boat sails out into the Una River. Below left, shops, government offices, and a marketplace line Valença's waterfront. A passenger on a ferryboat, below, has just purchased a fish from a fisherman in his dugout.

Luis Villota



Luis Villota



informal procedure for airing disputes called *olho do povo,* literally, "the community eye."

Liquid capital is almost nonexistent in swamp towns, so to make ends meet, fishermen fell back on elaborate borrowing/lending networks. Fishing etiquette involved a constant flow of small favors and gifts—towing in from the fishing grounds, lending bait, transporting the sacred wood of the white mangrove for use as a house beam, selling to a fish hawker on credit, or sharing premium water spaces during spawning runs.

Kinship and godparenthood relations further tied fishing captains together in friendship circles, which minimized disputes and legitimized territorial claims. Thus, by integrating daily observations of lunar-tide influence with elements of Portuguese, African, and Indian maritime lore, the isolated swamp communities built up an adaptive, stable system for fishing a tropical estuary. The system not only provided fresh fish for a limited market of sea and river ports but also assimilated and socialized new generations of fishermen in a reciprocal economy supported by cooperative fishing etiquette.

Introduction of the nylon nets changed all this. In less than a decade, this four-century-old tradition disintegrated. Although the nylon nets were originally intended for purchase by traditional captains, they eventually rejected the innovation, not out of inherent conservatism, but because they could not meet the loan-repayment schedules. Consequently, the nets fell into the hands of wealthy middlemen—factory bosses, plantation owners, and textile merchants—who could afford to speculate in fishing. Many fishermen, already indebted to these entrepreneurs, were drawn into an easily exploitable pool of cheap labor.

Over the next few years, a highly competitive nylon-net-fishing enclave grew up across the river from the traditional community where I



lived. Fishermen who had never been apprentices were put in charge of 30-foot dugouts. Discontinuing the customary system of dividing catches among crew members, nylon net bosses paid crews fixed wages, which although minimal by most standards, nonetheless appealed considerably to the security-minded peasant fisherman. Rent-free quarters were provided in a local factory compound. Between 1960 and 1965, 70 to 110 nylon net crews, using more than 600 new nets, were added to the traditional fishing system. But in the long run the anticipated replacement of fiber nets by nylon ones did not occur. Rather, too many nylon nets were added for the few water spaces available to accommodate them.

Fishery biologists generally agree that because of wide species distribution and the existence of planktonic larvae, overexploitation of stocks by traditional gear is unlikely. Under conditions of low population density, swamp communities had fished the same grounds since colonial times without having to shift their settlements because of resource depletion. Local waters are cyclically replenished by pelagic schools that seek out the sheltered reaches of the mangrove to feed and spawn.

In the ensuing struggle for control of the fishing grounds, the traditional ratio of fishermen to water spaces was shattered and the system of territorial claims disintegrated. The fishery reverted to the status of common property with all the attendant drawbacks of overcapitalization and overfishing. Cutthroat competition followed, with boats cast adrift on the tide and nets dynamited or slashed with machetes. The nylon drift nets set at night and allowed to float in the main channel were particularly hazardous to other set gear, easily snagging in the traditional trotlines and stingray nets.

Since they did not own their own equipment and were employed by a nonfishing power base, nylon net fishermen were willing to take greater risks and felt little responsibility for their actions on the fishing grounds. Economic warfare eventually took its toll. Traditional net fishermen were increasingly lured into high-risk stratagems they could not afford. Some decided to set aside their remaining equipment and wait out the strife.

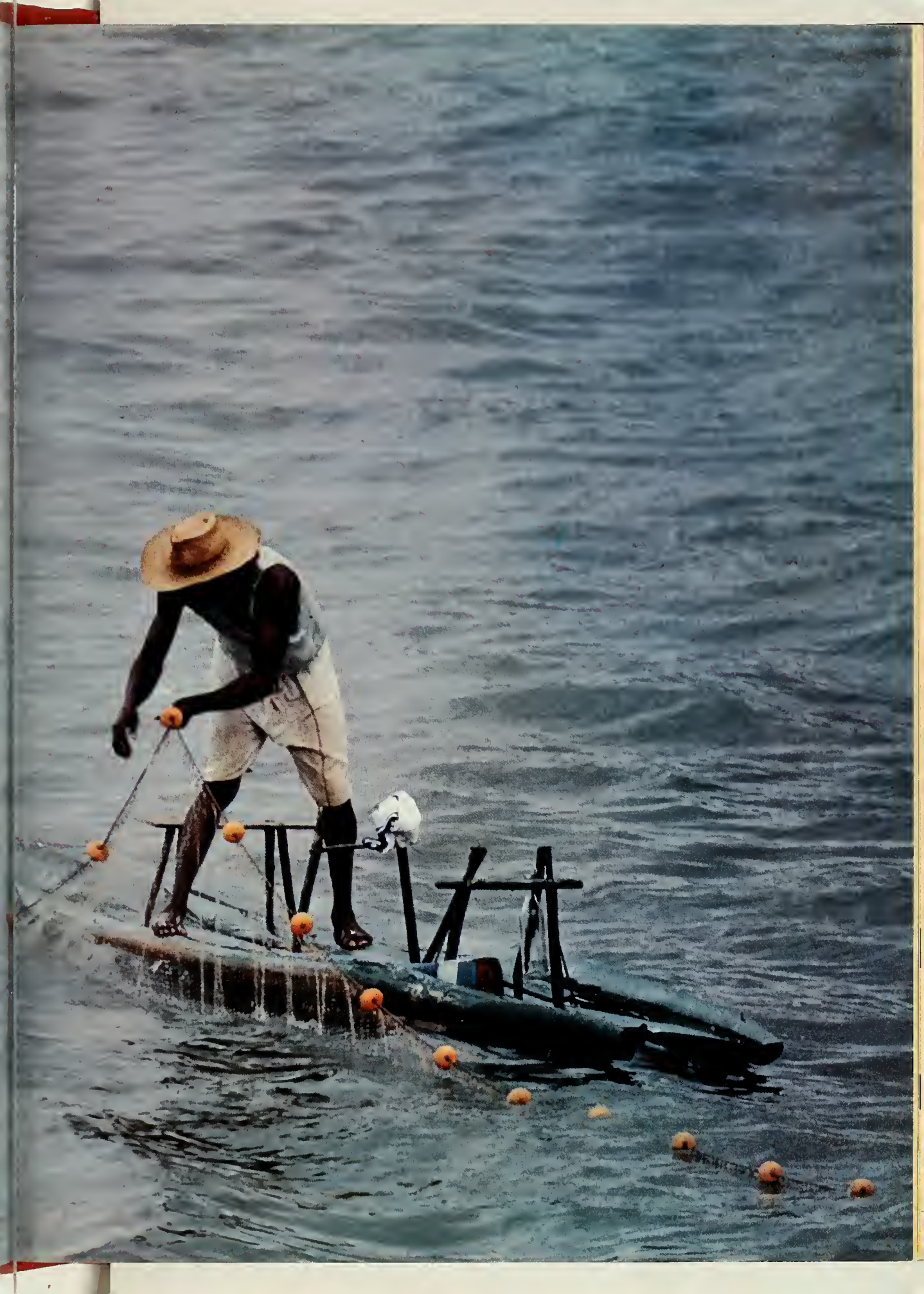
With the advent of nylon nets, overall production briefly increased but in time catches began to decline. Nylon net crews were laid off. Traditional captains, too, were forced to let their crews go and shift their operations to the recesses of the swamp itself: working small fish corrals with their wives, moonlighting as fish hawkers, combing the tidal flats alone with hand-cast nets, or scavenging for crabs, which to a net-fishing captain are animals hardly worth eating.

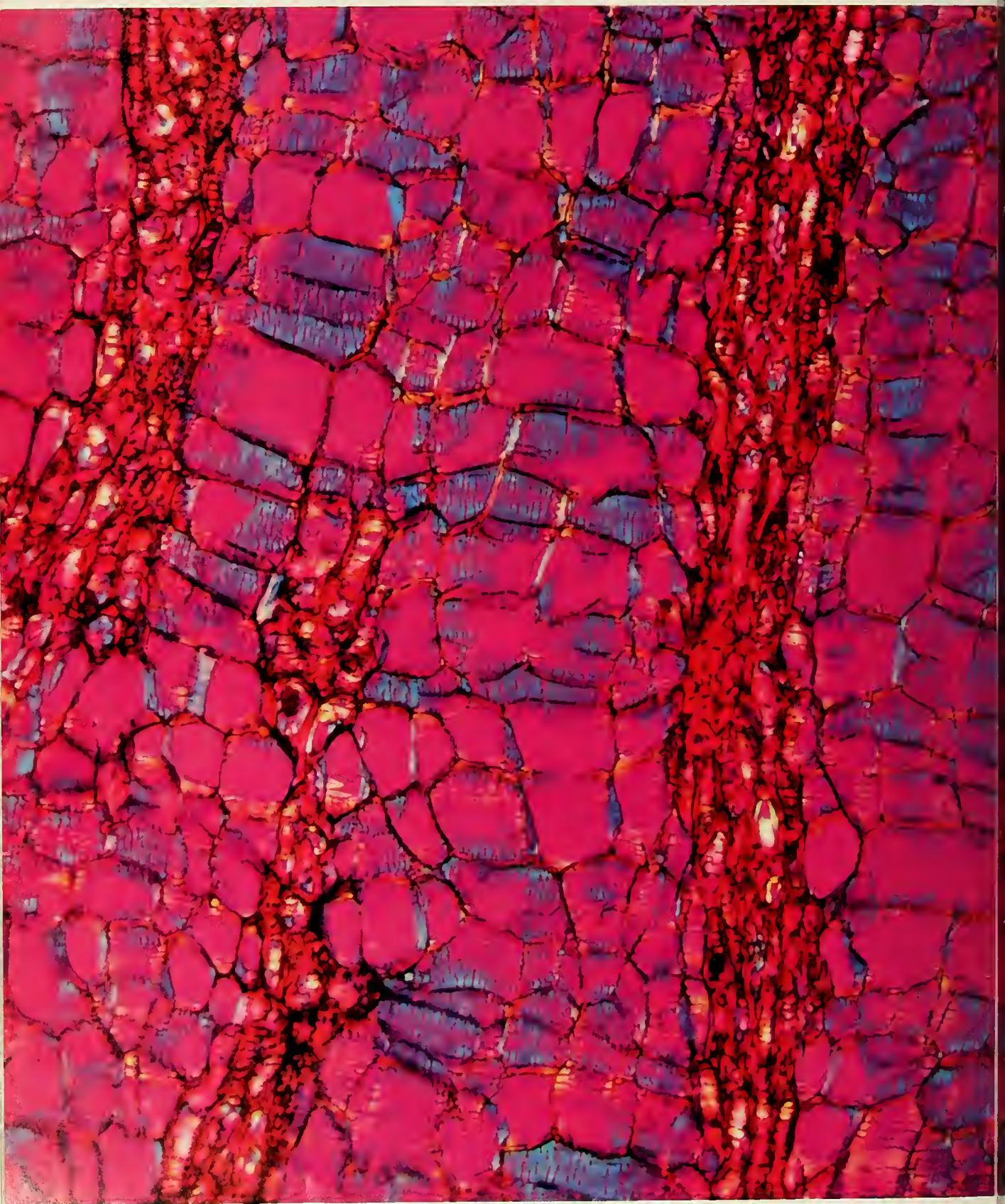
Lunar-tide fishing will soon be a lost art in Bahia as more and more energy is directed to individual, rather than community, survival. Whether the extreme phase of deculturation found in this segment of the Brazilian peasantry will be offset by a corresponding assimilation of new values, skills, and opportunities is still an open question. Highly specialized fishing knowledge, however, need not always be lost through speculative modernization. There is an alternative—preserving the traditional system and then building on that established base. Prior to the introduction of nylon nets, fishing captains in the swamps had partially solved the perennial problem of controlling access to the fishery by using a rigid fishing space tenure system that challenges usual common property theories. A strict cooperative ethic and long-term apprenticeship arrangements further reinforced their territorial claims. Today most swamp fishermen live lives of despair, while entrepreneurs, who have no long-term stake in the welfare of the fishery, have captured the swamp's most marginal subsistence resources, traditionally the reserve of the poor. □



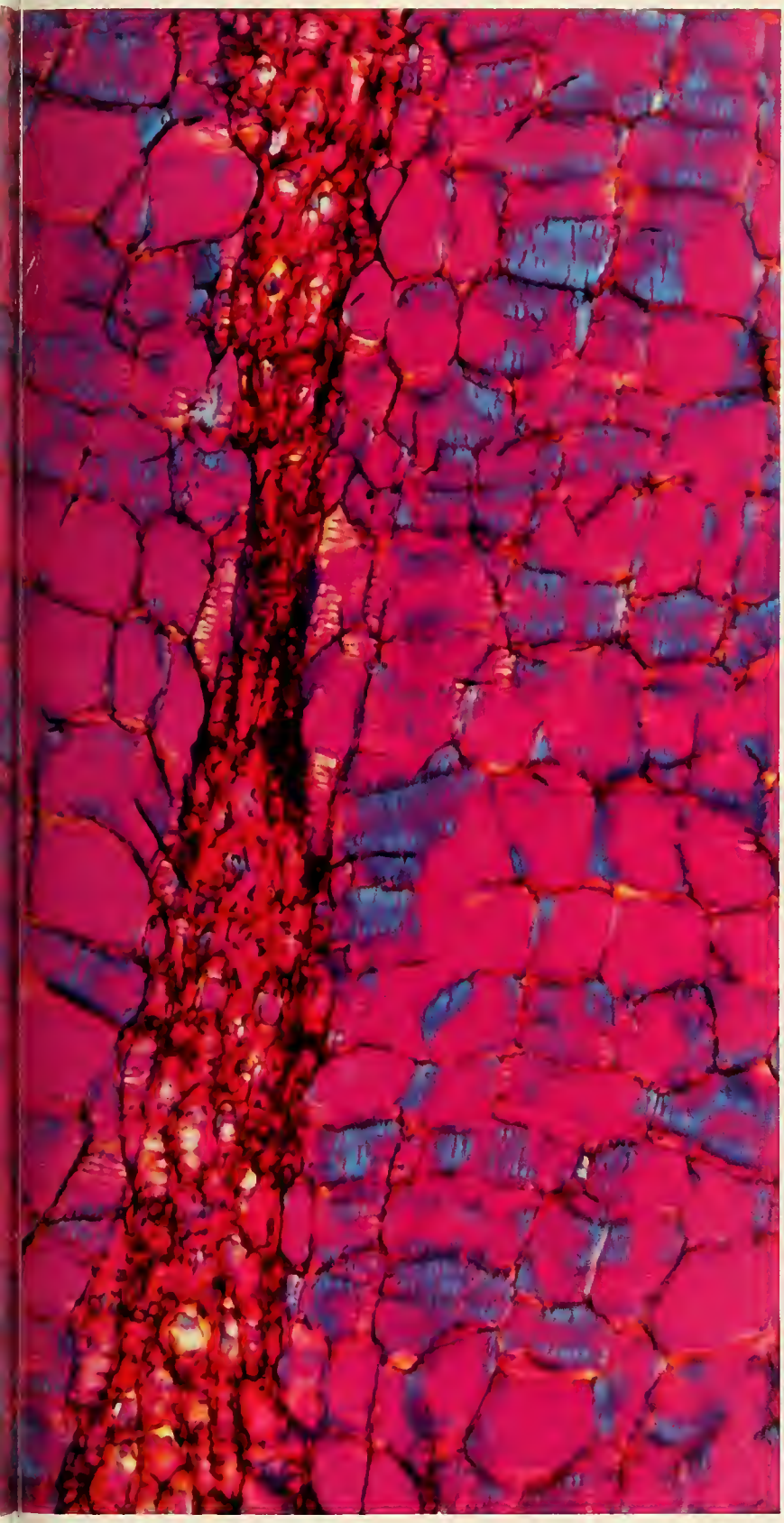
The swamp and river fishermen use small rafts as well as dugouts and sailboats when they work the fishing grounds.

Claus C. Meyer, Black Star





Transverse section of the bark of Magnolia grandiflora *(magnolia)*



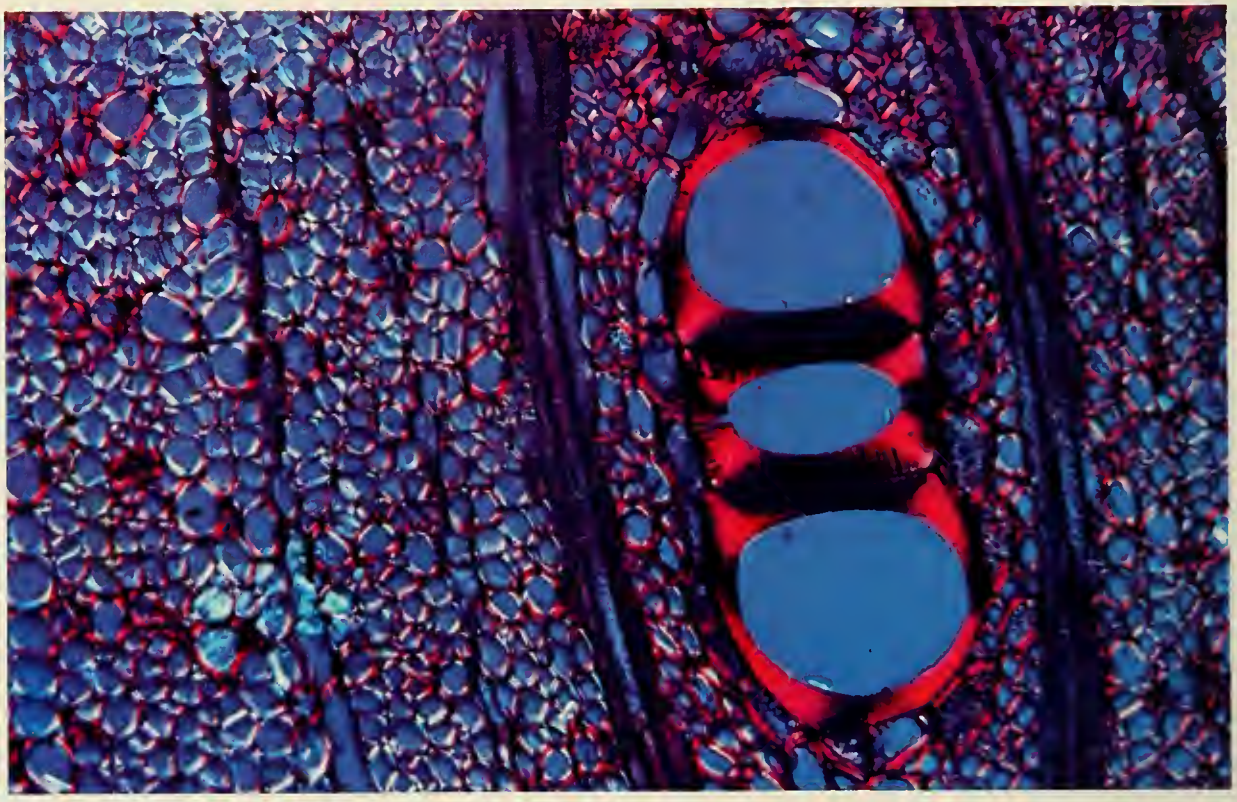
Plants in the Hostile Atmosphere

by Dan B. Walker

photographs by
William J. Dederick

The cells of land-dwelling plants must avoid death by desiccation

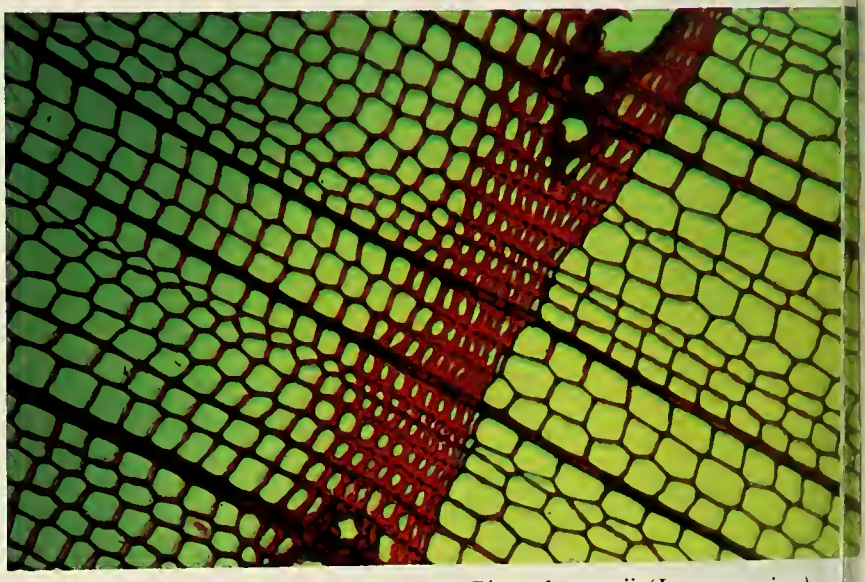
The basic life processes of trees and herbs are essentially the same as those of the smallest, most primitive plants, the single-celled algae. Although they differ vastly in size and are separated by hundreds of millions of years of evolution, both the tree and the algal cell manufacture their own food through photosynthesis, obtain their chemical energy through respiration, and synthesize living protoplasm by virtually identical enzymes and mechanisms. So similar are these organisms that even in its internal structure a single green cell from the leaf of a tree is nearly identical to a single algal cell. Both contain a characteristic nucleus, chloroplasts (the organelles that function in photosynthesis), mitochondria (the cellular sites of respiration), and assorted other, smaller organelles. Furthermore, each green cell from a leaf can perform its life functions independently, just as do the solitary algal cells. But if all basic life processes in plants take place in algal-like cells, how is it that trees differ so obviously from microscopic algae?



Transverse section of the wood of Diospyros virginiana *(persimmon)*

The answer is related not to how the cells function but to where they live on our planet. Algal cells live in aquatic environments, which protect against instant desiccation, while the cells of land plants must cope with the ever present danger of death by desiccation. Any unprotected living cell, plant or animal, placed in air will completely dry up and die within about thirty seconds. This means that all cells, of all living organisms, are strictly aquatic creatures. A terrestrial organism is merely a protective shell filled with up to millions of normally aquatic cells. Viewed in this light, a tree is a "vegetable skyscraper" that protects, and suspends, within its epidermal layers (the shell) millions of algallike green cells in an environment nearly as aquatic as that of the algal cell even though the hostile atmosphere may be but fractions of an inch away.

Other than the basic chlorophyll-containing photosynthetic cells (chlorenchyma) and a relatively few cells specialized for reproduction, all the myriad different cells and tissues in a plant function

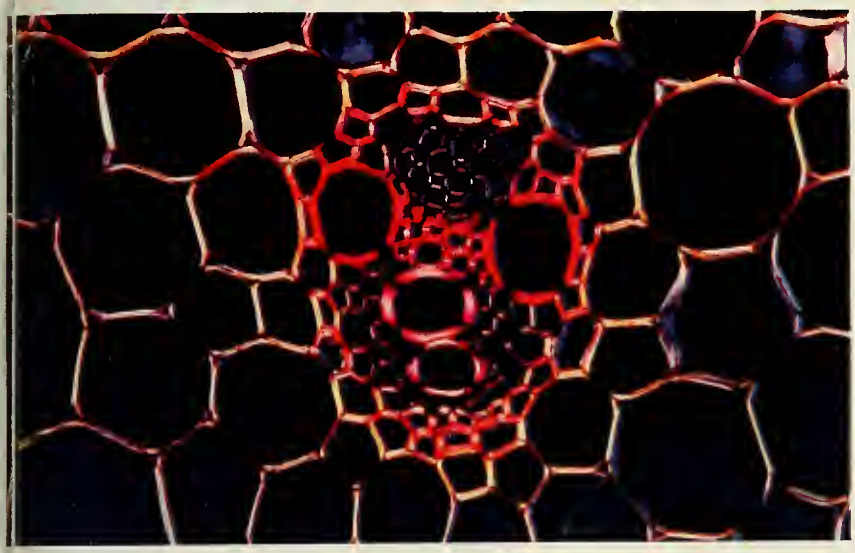


Transverse section of a growth ring in Pinus lawsonii *(Lawson pine)*

to create the required aquatic microenvironment, that is, they allow the plant to overcome the adversities imposed by the dry atmosphere or by competing organisms. Natural selection has resulted in a wide variety of trees, shrubs, and herbs—each a remarkable feat of engineering, each a self-contained "vegetable high-rise apartment building" that houses the chlorenchyma cells. And like self-contained apartment communities that house people, the vegetable high-rise must be equipped with life-support systems to provide for

its occupants. To better appreciate these systems, let us first examine the basic requirements for sustaining plant life and the difficulties encountered in the land environment.

What type of aquatic microenvironment is needed for the basic chlorenchyma cell to function properly? Only a very delicate balance of sunlight, temperature, mineral nutrients, and the atmospheric gases carbon dioxide and oxygen will suffice. Too little sunlight will not allow sufficient photosynthesis, while too much will cause heat or radiation damage. In the same manner, too few mineral nutrients severely limit growth, while excessive amounts of certain minerals are toxic. At certain times carbon dioxide must be absorbed and oxygen eliminated, while at other times the reverse must take place. Freezing temperatures will cause damaging ice crystal formation, while excessively high temperatures will destroy sensitive cellular components.

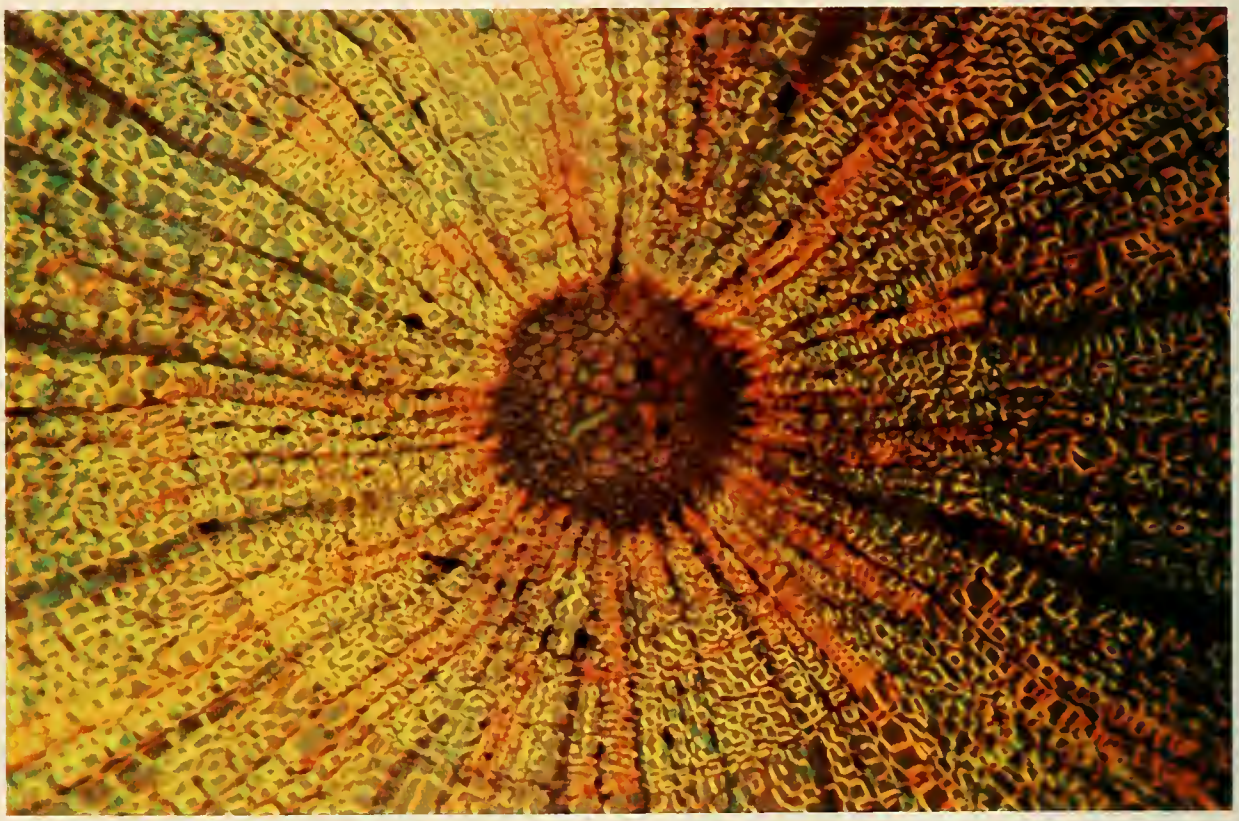


Transverse section of a vascular bundle in the leaf of Ammophila breviligulata *(beach grass)*

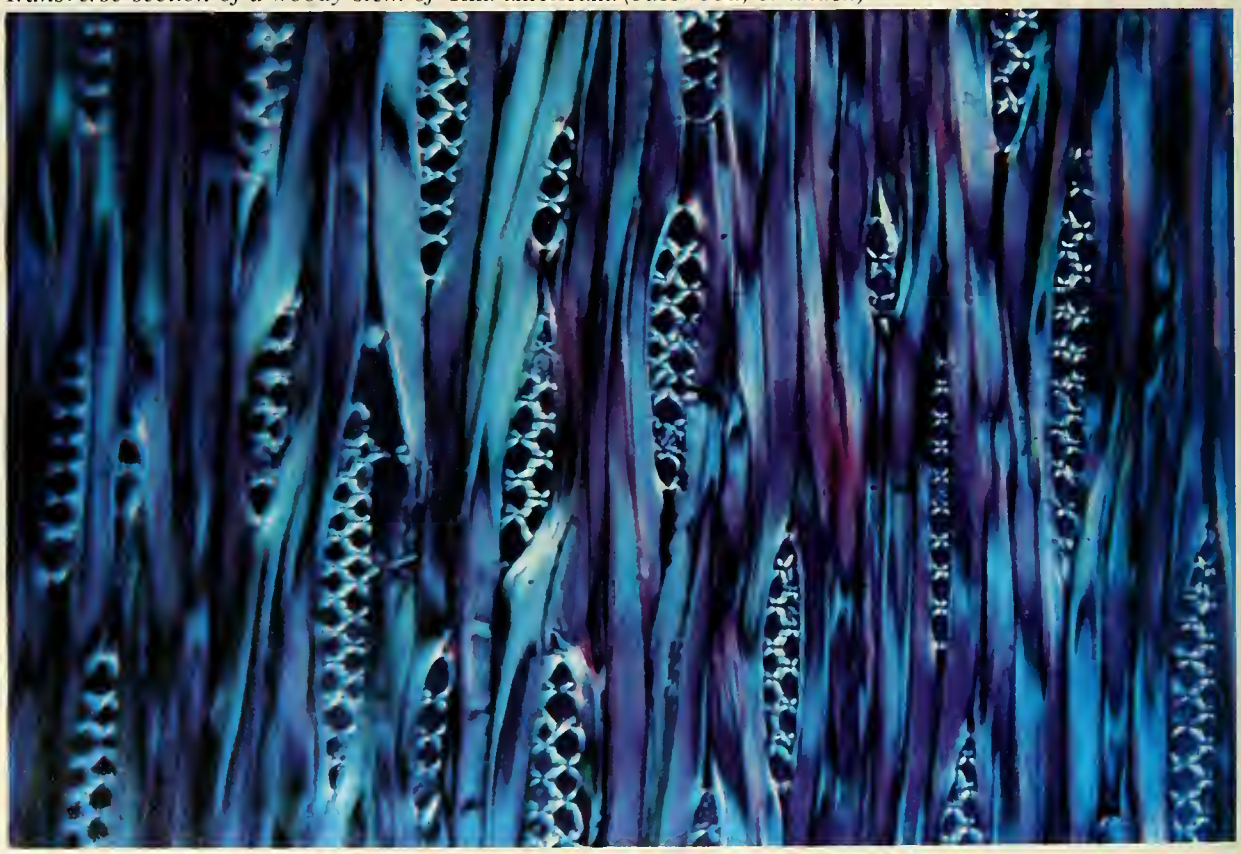
Few such balanced environments occur naturally, and it is to these locations—predominantly the surface waters of our planet or constantly moist soil surfaces—that the algae are restricted. Only near the interface of the water and the atmosphere can sunlight reach the cells and sufficient gas exchange occur. Because gases diffuse very slowly through liquids, plant life in stagnant water may be restricted to within a few feet or less of the surface. By contrast, in actively aerated water, plant life can extend to the submerged edge of darkness—more than 200 feet deep in the clearest waters. Nevertheless,



Tangential section of the wood of Acer saccharum *(sugar maple)*



Transverse section of a woody stem of Tilia americana *(basswood, or linden)*



Tangential section of the wood of Fraxinus americana *(white ash)*

when one considers the immense thickness of the planet and its atmosphere, these surface waters are but a minute film.

The aquatic microenvironments created internally by the plants extend the plant cells' life zone vertically many feet from the surface of the planet—more than 300 feet in the case of the tallest trees. Since the natural life zone for plant cells consists only of the top quarter-inch or so of constantly moist soil (a rare soil condition at best), land plant architecture dramatically increases the habitable space by many, many times. Each plant is literally an aquatic oasis within the desert of the atmosphere, an oasis inhabited by the algallike cells. And since terrestrial animals are dependent on the food and oxygen produced by the algallike cells through photosynthesis, each plant is an oasis that supports animal life as well—ourselves included.

Maintaining an aquatic microclimate within a structure as highly branched as a tree is a problem to challenge the best of engineers. Not only must every leaf cell receive a continuous water supply from the root system, but every root cell must concurrently obtain photosynthetic products from the leaves. Since the aerial portion of some trees is more than 300 feet long and the roots an additional 200 feet, the transport pathway may stretch in excess of 500 feet. If the lengths of all stem and root branches, plus the veins of the leaves, are added, the intercellular highway system in a single tree is thousands of miles long. Furthermore, imagine the mechanical difficulties associated with supporting a skyscraper the shape of a tree. What unique architectural specializations does the vegetable high-rise possess, and how do they compare with the designs of our mechanical engineers?

Structural support is a major requirement for any dwelling. Without support the smallest vegetable enterprise protruding vertically an inch or more into the atmosphere would be toppled by the strong force of gravity and the shearing force of winds. In the absence of foraging animals or of competition for space and light with other plants, a prostrate herb might (and some do) survive admirably; however, the 300 to 400 million years of land plant evolution have resulted in a tremendous species diversity that makes survival difficult for all plants because of intense competition for raw materials and real estate. Although diminutive plants still have a place in nature, the space race for plants, like that for humans, clearly resulted in construction of the vegetable skyscraper. Such high-rise architecture contains increased office space (leaves) and also towers above the herbaceous congestion that competes for the available sunlight.

The supportive tissues, or girders, that make such architecture possible consist of specialized elongate cells with greatly reinforced cell walls. Unlike an animal cell, each plant cell is surrounded by a supportive shell, or cell wall, made of cellulose and a mixture of other carbohydrates, protein, and in some cases, lignin. This enclosing shell acts as an exoskeleton for each cell and constitutes the skeletal system of all plants. By contrast, the higher animals have an endoskeleton of bone and cartilage that acts as a framework on which to hang the many individually nonsupported animal cells.

The specialized supportive cells in plants have cell walls constructed much like reinforced concrete. Both contain long solid rods that are carefully oriented within a surrounding matrix of congealed material. In a plant cell wall the solid rods are long thin needles of cellulose called microfibrils; in concrete the rods are steel. For added strength in a given direction, the cellulose microfibrils are aligned in parallel array within a single layer of the wall. Most thick walls have several layers, and the different layers often have the cellulose microfibrils oriented at different angles for multidirectional strength. (The same engineering principle is often used when pouring concrete.) The cellulose rods are embedded within a gluelike matrix consisting of amorphous carbohydrate (hemicelluloses and pectins), protein, and often lignin (a complex polymer especially characteristic of wood). But whereas concrete is a congealed solid (of cement and sand or gravel), the matrix of the cell wall is a colloid with a thick gellike consistency, held together as a mesh by chemical bonds between the various constituents. The wall's fluid nature imparts a desirable resiliency to the structure—thus wood is less brittle than most concrete. The quality of the final product is attested to by the thousands of uses to which we put lumber and wood products.

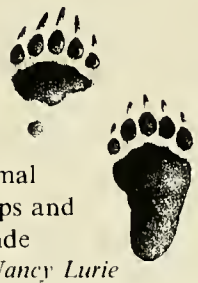
Several types of cells within the plant possess supportive walls like those above, the most common being sclerenchyma fiber cells and xylary (water-conducting) cells. The long and needlelike fiber cells occur in bundles; when exploited by man, they are called commercial fibers. Economically important examples of such fibers include flax for making linen; hemp for cordage; jute for cordage or textiles; and ramie for textiles. Fiber cells are also a major component of many hardwoods, such as oak and walnut, and contribute much to their structural properties.

While only a few fiber bundles may suffice to support a small herbaceous plant, the wood of shrubs and trees contains enormous quantities of supportive tissue. However, wood, or secondary xylem, serves another major function in maintaining the land-based plant, that of establishing aquatic continuity with the soil. Thus wood is a mixture of supportive tissue, such as fibers, and water-transporting tubes, or xylary cells.

Xylary cells vary greatly in size and shape: one extreme resembles the elongate fiber cell, while the other is shaped like a wooden barrel open at both ends. Some barrel-shaped xylary elements can be quite large; in oak lumber they are macroscopically visible as the familiar "pores." But regardless of size, all functional xylary cells are dead, hollow, and arranged in continuous files to form the complex water-pipe system of the skyscraper, which extends throughout every leaf, branch, and root and is continually being added to in every growing region of the plant—all this without interrupting consumer service.

Just as buildings have a second plumbing system, the sewer system, to transport products away from active sites of synthesis, so plants have a second system, the phloem, for transporting (in this case *desirable*) metabolic products such as sugars and amino acids from sites of manufacture to sites of cellular construction or storage. Unlike xylary cells, phloem cells are living and contribute little to the structural support of the entire community. Nevertheless, they are the major conduit for food transport throughout the plant body. Together, the xylem and phloem constitute the circulatory, or vascular, system of the plant, and each reaches to within several cells of every cell in every leaf or branch of the plant. Upon reaching these terminal faucets, the vein endings, the transported materials must be either handed from cell to cell or must diffuse through the cell walls in order to reach the individual cells. This is not unlike the terminal circulatory system in animals where minute capillaries release the transported materials, which must then pass by diffusion to the individual surrounding cells, while at the same time cellular products must diffuse back into the capillary system.

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But while the higher animal vascular system continuously recirculates the same fluids—the arteries carrying blood from the heart and the veins carrying blood back to the heart—the sap of a plant is not continuously recirculated. The plumbing systems of the plant, the xylem and the phloem, operate largely independently of each other, are not interconnected, and carry different substances. The xylem sap and phloem sap can move in the same direction or in opposite directions in a given tissue depending on the particular nutritional requirements of the tissue. Furthermore, the direction of flow can change with the time of day or the season of the year. The supply and demand of the tissues involved, not a central heart, regulates the direction of flow.

Plants also differ markedly from animals in other ways. Plant circulatory systems do not transport oxygen (O_2) and carbon dioxide (CO_2) to or from the tissues and plants do not have lungs to perform atmospheric gas exchange. Nevertheless, exchange of both oxygen and carbon dioxide with the atmosphere is as important to plants as to animals.

During the day, carbon dioxide must be absorbed by the green cells for conversion into sugars and, ultimately, all the other organic molecules that make up the plant body. Concurrently, the oxygen, a byproduct of photosynthesis, must be released from the tissues because high concentrations of oxygen inhibit photosynthesis. During the night, gas exchange in plants is similar to that in animals because the process of cellular respiration is the same for both groups. Oxygen is taken into the cells and used in the oxidation of organic molecules such as sugars in order to release the chemical energy that operates all life processes. Carbon dioxide, a product of respiration, is thus released from the tissues.

Like animals, plants perform respiration at all times of the day or night since chemical energy is continuously required. However, while the green plant is photosynthesizing during the day, the net gas exchange is in favor of the photosynthetic process (uptake of CO_2 with release of O_2). Only at night when photosynthesis is not occurring does net gas exchange reflect the respiratory process (uptake of O_2 with release of CO_2). Thus, energetically, photosynthesis and respiration are roughly the reverse of each other. During photosynthesis the energy in sunlight is captured to manufacture sugars and oxygen, and during respiration, oxygen is utilized to combust the sugars and release chemical energy. Since animals cannot perform photosynthesis, all animal life is totally dependent on green plants for continual replenishment of the oxygen supply and for all primary food production.

Providing a means for this necessary gas exchange is perhaps the most serious problem faced by the land plant because our vegetable skyscrapers must not only provide for exchange of gases with the atmosphere but also protect the aquatic microenvironment from the severe drying effects of this same atmosphere. Because these two considerations are directly at odds, no perfect solution is possible—there must be a compromise between unavoidable transpiration (water loss) and adequate levels of gas exchange. The actual degree of compromise varies from species to species, depending on such factors as the amount of available water, the temperature and drying effects of the outside atmosphere, and the growth rate necessary for survival (growth being limited by reduced gas exchange). Furthermore, these factors may change daily, often hourly, making the land environment even more challenging for our aquatic invader.

The plant's adaptation to these formidable difficulties is the epidermis, a remarkable, normally single layer of cells that carefully controls the degree of compromise through the use of millions of microscopic, adjustable ventilation pores, or stomates. The stomates of most plants consist of a slitlike pore

formed between two kidney-shaped guard cells. It is the unique property of guard cells that they can expand or contract, thus opening or closing the ventilation pore in a valvelike manner. Equally amazing is that these minute guard-cell pairs function like minicomputers, detecting and balancing the effects of all interacting factors, such as the severity of water loss, availability of internal water, concentration of carbon dioxide in the tissues, and whether the plant is in light or darkness.

All of this information is integrated simultaneously (not electronically, but chemically) so the green, algallike cells that inhabit our high-rise community are always provided with the best compromise between water loss and gas exchange. Furthermore, all the stomates of a leaf act in unison even though there are from several thousand (in grass plants) to more than one hundred thousand stomates (in certain oak trees) on each square centimeter of leaf surface (usually the lower surface). The efficiency of this complex water/gas exchange control system is apparent from the abundance and universal location of vegetation on our planet.

Below the stomatal ventilation pores is a ramifying system of ventilation ducts, called intercellular spaces. With rare exceptions, all cells in the entire plant body, from the leaves to the roots, border on the interconnected ventilation duct system, just as do all rooms of a building. This is necessary to achieve adequate gas exchange; otherwise the cells would suffocate and die. Hydrophytes have especially acute gas exchange problems. Because gases diffuse very slowly through water, the ventilation system in many hydrophytes is greatly expanded by aerenchyma tissue, in which the air-filled ventilation ducts often occupy more volume of the plant body than do the cells. Architecturally, aerenchyma is a beautiful blend of complexity and geometric regularity that rivals anything man-made.

Thus the interior of the land plant is a very unusual aquatic microenvironment. The surface of every cell is covered by a saturating film of water; yet every cell is adjacent to the air-filled ventilation spaces that facilitate rapid exchange of carbon dioxide and oxygen. The drying effects of the air in the ventilation spaces are minimized, however, because the air's relative humidity is maintained at nearly 100 percent. Should excessive water loss cause the relative humidity to drop, even slightly, the stomatal valves will close, partially or completely, until the water balance is reestablished within the leaf.

The stomatal regulators in the epidermis, together with the supportive and vascular tissues, make up the major life-support systems for plants that have invaded the atmosphere. This invasion of the land is exactly the reverse of man's construction of underwater cities within domes or tubes in order to extend an atmospheric environment into the normally aquatic environment. Many of the same engineering principles apply to both.

The similarities between natural systems and man's solutions to engineering problems should demonstrate to all of us that humanity can benefit greatly by studying the laws of nature. □

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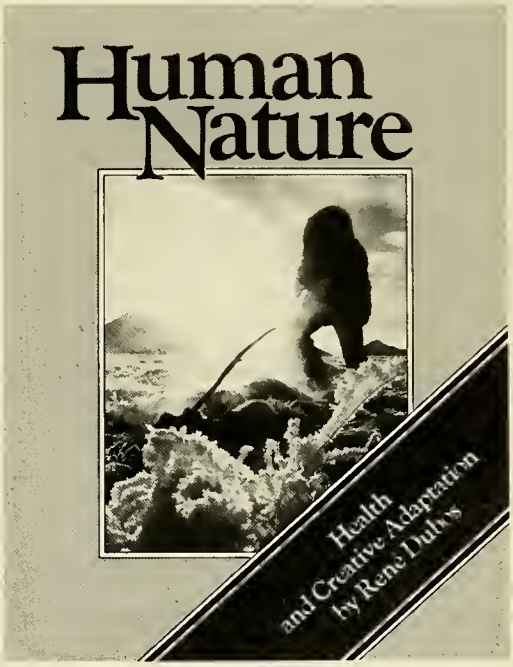
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Now You See It; Now You Don't

The first-known long-period variable star, discovered more than 300 years ago, continues to baffle astronomers

Almost four centuries of study have determined many properties of Mira and other long-period variable stars, but the process that causes cyclic changes in their brightness is still uncertain. Recent work indicates that shock waves, traveling outward through these huge stars from pulsating regions deep inside, may trigger transparency changes that make the stars seem to alter in size.

Mira, the first-known long-period variable star, was discovered by a German astronomer-clergyman, David Fabricius, in August 1596; at least, that's when the star became known to Western science. But according to one interpretation of an old cuneiform text, Mira's curious habit of alternately fading from view and reappearing may have been recognized by the ancient Babylonians. Fabricius knew only that he had found a fairly bright—and yet apparently uncataloged—star in the constellation Cetus the Whale, and that it faded from view over the next two months. Since he had trained under the great Danish astronomer Tycho Brahe, famous for his study of a "new star" that appeared in 1572 and then vanished forever, Fabricius probably thought that Mira was a similar object. In February 1609, however, he must have changed his mind when he glimpsed Mira again.

Other persons must also have seen the star in the interim because we now know that it varies periodically in brightness, reaching a "maximum light," which is readily visible to the unaided eye, once every eleven months. Further, the noted *Uranometria,* an accurate and beautiful sky atlas printed in 1603, shows Mira as a dim star in the neck of Cetus, labeled only by the Greek letter omicron and without any notation that the compiler of the atlas knew the star was unusual.

As its remarkable properties were established, omicron Ceti was often called Mira (abbreviated from *stella mira,* Latin for "wonderful star"). Sometimes, however, it was described as "The Periodical Star in Collo Ceti [the whale's neck]." That's how the noted astronomer Sir William Herschel referred to the star in a series of late eighteenth-century reports to the Philosophical Society of Bath in England. I am not sure that whales have necks in the usual sense, but, then as now, astronomers were not required to include zoology among their qualifications.

Herschel found that Mira's intensity at its periodic maximum brightness was itself variable; in some years the star became much brighter than in others. On one rare occasion, it actually rivaled the first-magnitude Aldebaran, the bright red star in the head of Taurus the Bull. Herschel tried to study Mira telescopically at those times when it faded from naked-eye view. In 1780, at two o'clock on an August morning, he "looked with a compound eye piece that takes in a very large field of view, and examined every very small star near the place of the periodical star but could not find it." One month later to the day, he was able to discern the star by unaided vision and easily trained his telescope on it. He wrote of this observation that Mira had a deeper red color "than any I remember to have seen before among the fixt Stars."

The red color was an important clue to Mira's physical properties, for red stars are cool ones. Today more than three thousand similar stars have been found, with periods of cyclic brightness-change ranging from fewer than 150 to more than 1,000 days (thus, the term "long period," which distinguishes these from other kinds of variable stars that undergo more rapid fluctuations). They are identified as a variety of red giant stars, with diameters far larger than that of the sun, but with roughly equal mass. The mass of a red giant star such as Mira is concentrated in a small, dense core, but the thin outer layers extend so far outward that, were the star placed at the center of our solar system, it would engulf the planet Mars, well beyond the orbit of the earth. Much effort has been expended in attempting to explain the brightness variations in long-period variable stars, although such investigations often ignored Herschel's important finding that the maxima were unequal.

These investigations required ever more sophisticated techniques, including spectroscopy, the analysis of starlight to determine the temperature and chemical composition of a star and to estimate motions in its atmosphere by means of the Doppler effect; interferometry, a method for measuring the apparent diameter of a bright star; and infrared photometry, the measurement of a star's infrared radiation. The first spectrogram of a long-period variable star (Mira, in fact) was obtained at Harvard in 1885, and Mira's diameter was measured at Mount Wilson Observatory in 1919. Infrared measurements were also carried out at Mount Wilson, beginning in 1921.

From the many spectrograms made since 1885, we have learned that gases in the atmosphere of Mira move up and down over the eleven-month cycle of brightness changes. This finding gave no support to an early theory that ascribed the brightness variations to the growth and dissipation of starspots on Mira, an idea patterned after the observed sunspot cycle of our sun. Nor was there any hard evidence

by Stephen P. Maran

for a proposal that the brightness changes were due to rotation of the star. For the purposes of this theory, Mira was imagined to have a distorted and changing shape and to be on the brink of splitting in two, to form a binary star. Instead, the observation of rhythmic motions suggested that Mira was pulsating, like the better-studied variable stars of shorter period, called cepheids.

A pulsating star bulges in and out; in the absence of complicating effects, it is coolest (and therefore faintest) when it is largest since expansion cools the gas. A possible drawback in applying this explanation to Mira was the knowledge from Herschel's studies that Mira's visible light changes by a factor of 250 or more from maximum to minimum in a typical eleven-month cycle. By contrast, the pulsation theory predicts a change of only a factor of 40. This objection, however, appeared to be satisfied by the discovery of strong and variable absorptions of light due to the titanium oxide molecule, which is abundant in the atmospheres of Mira and other long-period variable stars.

When a gas is heated above a certain temperature, its molecules break up into their component atoms, which rejoin each other to form molecules again when the gas cools below that temperature. The spectra of Mira taken at different times in its cycle showed that the titanium oxide absorptions were stronger (indicating that more molecules were present) when the star was in its cool, dim phase. The absorptions were much weaker (implying the presence of far fewer molecules) when the star was hot and bright.

In addition, when the star is cooler, solid particles of "stellar dust" may form from the gas at high altitudes in Mira's atmosphere, much as water vapor condenses to form cirrus clouds of tiny ice crystals at the colder levels of the earth's



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atmosphere. The stellar dust tends to evaporate when the star gets hotter. Thus, the dust, too, cuts off more of the star's outward streaming light when the star is cool and absorbs less when the star is hot.

The molecules and the dust, together with the basic warming and cooling of the pulsating star, were thought to explain Mira's full factor of 250 light variations. While not accorded the status of a proven theory, this pulsation hypothesis became the leading explanation for the brightness changes of long-period variable stars.

Interferometry measurements showed that, when bright, Mira has a diameter about 460 times that of the sun. Since the technique was not applicable when Mira became faint, diameters were inferred from infrared photometry done at different times during the eleven-month cycle. These observations were readily performed even when Mira was faintest, for the Mount Wilson astronomers discovered that the infrared light of the star changes by a factor of only 2½ during a cycle, fully 100 times less than the visible light.

Unfortunately for the survival of the pulsation theory, these measurements showed that instead of being largest approximately when coolest, Mira was largest relatively soon after reaching its maximum brightness and hottest temperature. Another objection to the pulsation theory is the variability in Mira's intensity at maximum light, as noted by Herschel. Stars definitely known to be pulsating, such as the cepheids, have changes that generally repeat with high precision, like the swings of a pendulum, and we should expect no less from Mira if it is pulsating.

The final blow to the pulsation theory was a detailed analysis, published last year, of the motions of the gas in three long-period variable stars. This study by George Wallerstein, a leading expert on stellar atmospheres at the University of Washington, examined the following point: If a star is pulsating, the observed motions (found by spectroscopy) must correspond to the changes in the diameter of the star, as implied by infrared photometry. Further, the motions must proceed at such speeds that what goes up will come down before it goes up again in the next cycle. Wallerstein found that none of the three stars he studied satisfied both of these conditions. This raised the specter that the apparent size changes of long-period variable stars do not correspond to actual changes in the diameters of the stars but are an illusion caused by the manner in which we perceive the diameters. (The manner of perception is as follows: We measure the temperature and infrared brightness of a star, then calculate how large a surface at the given temperature is required to produce the observed brightness.)

Wallerstein's findings are in agreement with what is known as the shock wave theory. According to this theory, the observed changes in size are due to shock waves that travel outward from the deep interior of a long-period variable star, rather than to pulsations of the observed outer layers. A shock wave is a disturbance that travels through a medium (in this case, the hot gases of the star) at a speed that exceeds the speed of sound in that medium. Like the consequences of sonic booms from fast-moving jet planes, the effects of shock waves are not the same on every occasion. This agrees with the observation that the brightness of Mira has different peak values in different cycles.

It has been suggested that the shocks are produced by periodic nuclear explosions in the core, but this idea is not confirmed by detailed computations. A more likely possibility is that the core and a surrounding zone, deep inside the star, are pulsating in the manner of a cepheid variable star, but these pulsations are screened from view by the overlying layers of gas. As the pulsations travel outward they move through regions of decreasing density and become more powerful disturbances, just as a small deflection near the handle of a bullwhip becomes a violent snap when it reaches the whip's tip.

The outward-moving and intensifying disturbance becomes a shock wave when it reaches a certain upper level of the star. It heats the gas far above that level, thus contributing to the brightness changes that we observe. The upper layers of the star, however, are not pulsating, since the pulsations have given way to shock waves. Instead, they are reacting to the increased heating occasioned by the periodic arrivals of the shocks. According to the shock wave theory, the dominant reaction is a decrease in the number of molecules and dust grains caused by the heating. Immediately after maximum temperature occurs, the atmosphere begins cooling, dust and molecules form in abundance again, and the atmosphere becomes more opaque. With increased opacity we are unable to see to as great a depth as previously; as a result, the star seems to be bigger. Actually, it is the star's visible extent that has varied because the upper layers have changed from transparent to opaque.

The shock wave theory appears to be an adequate explanation for the properties of a long-period variable star, as established by extensive past observations, although it may not be the last word on the subject. However, recent studies with infrared and radio telescopes have revealed a whole new set of unexpected phenomena. For example, despite its enormous size, Mira is found to be dwarfed by its own giant circumstellar shell of gas and dust, like a small light bulb at the center of a large globular lampshade. This shell may be produced by the pressure of Mira's light, which conceivably drives stellar dust outward from the star just as the pressure of sunlight pushes the dust tail of a comet in the direction opposite the sun. Or the material may be driven outward by the shock waves.

Water vapor, hydroxyl (OH), and silicon monoxide molecules in the shell appear to beam intense radio waves via naturally induced maser processes, which remain unduplicated in earthly laboratories. Also present in the shell are carbon monoxide molecules aglow with radio waves, stimulated by the influence of infrared light from the star, just as certain minerals glow in the dark when illuminated by ultraviolet light. Studying these marvelous phenomena will keep us busy for years to come and explanations may still be incomplete in 1996, when astronomers celebrate the four hundredth anniversary of Fabricius's discovery of the wonderful star in the neck of the Whale.

Stephen P. Maran is senior staff scientist of the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

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Celestial Events

by Thomas D. Nicholson

Sun and Moon The sun is in the constellation Taurus until June 21, in Gemini until July 20, in Cancer until August 10, and in Leo thereafter. It arrives at the summer solstice at 1:10 P.M., EST, on June 21, the longest day (from sunrise to sunset) of the year and the beginning of summer in the Northern Hemisphere. The earliest sunrise occurs on June 14, however, and the latest sunset on June 28. On July 5, when the earth arrives at aphelion, the sun will be at its greatest distance from the earth, about 94½ million miles.

The moon will go through change early in each month this summer. The evening moon (as a crescent) will appear about the beginning of the second week—growing, brightening, and remaining later until full moon occurs after midmonth; then waning, dimming, and rising later as a morning moon through about the last week. Lunar phases are:

New Moon	June 5	July 5	August 3
First-quarter	13	13	11
Full Moon	20	19	18
Last-quarter	27	26	25
Apogee	8	5	1 and 29
Perigee	21	19	17

Stars and Planets The evening planets, so prominent earlier this year, will now become less conspicuous. In early June, you will still find Venus (the brighter) and Jupiter close together and well placed in the sunset sky, with Mars, Saturn, and the star Regulus (all in Leo) higher, to the left, and very close to each other. But during June, Jupiter sets earlier each night and soon disappears as an evening star. Venus, meantime, is still brightening and shifting farther from the sun and also moving to a part of its orbit unfavorable for evening viewing. Mars, now only half as bright as Saturn, is also moving swiftly eastward, away from Saturn. It moves into Virgo before the end of July. But Saturn will not be alone for long. Venus moves close to it in early July, passing it on the 10th. In mid-August, Venus catches up to Mars.

June 4: Mars and Saturn are in conjunction.

June 7–8: The moon moves past Jupiter and Venus.

June 11: Saturn, Mars, and Regulus are very close above the moon.

June 12: Mars is in conjunction with Regulus.

June 14: Mercury, in superior conjunction, enters the evening sky. All eight planets are now evening stars (above the horizon at sunset).

June 21: Summer begins at 1:10 P.M., EST, north of the equator.

July 8–10: On these evenings, Venus, Saturn, and Regulus will be exceptionally close, with Mars not far to their left, low in the western sky after sundown.

July 18: Saturn passes Regulus tonight, moving from the star's right (where it has been since January) to its left.

July 19: Perigee moon occurs only six hours before full moon.

July 21: Mercury is at its greatest distance to the left of the sun.

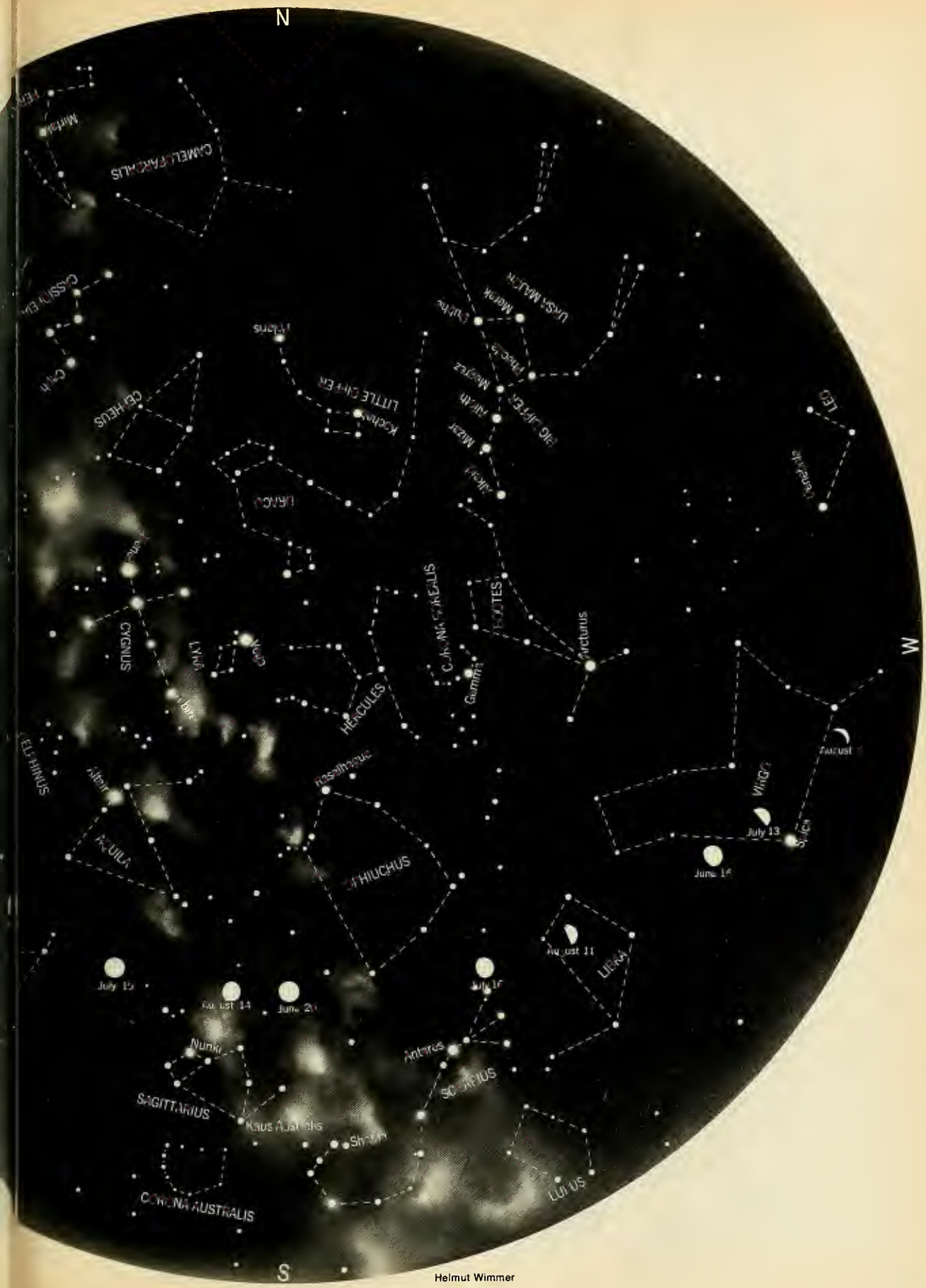
July 29: The Delta Aquarid meteor shower will reach maximum this morning (about 20 per hour).

August 7: The crescent moon is very close to Venus and Mars tonight, covering both planets in turn.

August 10–14: Best days for viewing the Perseid meteor shower. Maximum (about 50 per hour) will be on the 12th.



★ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 1:20 P.M. on June 1; 12:25 P.M. on June 15; 11:25 P.M. on June 30; 10:25 P.M. on July 15; 9:20 P.M. on July 31; and 8:25 P.M. on August 15; but it can also be used for an hour before and after those times.



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The War Between Indians and Animals

by Calvin Martin

Early Canadian fur traders reaped a bonanza because some eastern tribes revenged themselves against wildlife

Over the past five centuries the American Indian has been called everything from "noble savage" to "besotted alcoholic"—epithets that say as much about the conscience of contemporary white society as they do about the state of the Indian. So it was that in the heat and froth of the 1960s environmental movement, yet another title—"ecological Indian"—was conferred on the idealized native American, who was paraded out before an admiring throng and hailed as the high priest of the Ecology Cult. According to law professor Rennard Strickland, "*It is not an accident that the idea of ecology and the ideal of the Indian should emerge simultaneously as national issues,*" and former Secretary of the Interior Stewart Udall concurred. Both Indian activist Vine Deloria, Jr., and Kiowa novelist N. Scott Momaday urged white Americans to "adopt Indian ways to survive."

Critics of the ecological Indian were quick to respond. In 1972 the frontier historian W. H. Hutchinson expressed a strongly negative opinion in his "Dissenting Voice Raised Against the Resurrection of the Myth of the Noble Savage." A past master of sarcasm and metaphor, Hutchinson blasted the dewy-eyed romantics who would claim for the Indian such a delicate ecological conscience "as to make the Sierra Club seem an association of strip miners by comparison." Nature, as he cogently put it, "is *not* a benign bovine with a teat for every questing mouth!" Hutchinson went on to say that the Indian revered nature because he had no other choice; that he perceived nature as being controlled by supernatural forces that he was obliged to propitiate if he hoped for success in life; failure to perform the proper rituals, adhere to taboos, and conduct ceremonials was tantamount to inviting disaster. We ought to dry our eyes and recognize that the Indian was above all a self-centered pragmatist when it came to land use.

Hutchinson ended his assault with a troubling question: "If the Amerind was a truly dedicated ecologist, why did he so succumb to the artifacts offered him by Europeans that he stripped his land of furs and pelts to get them?" His answer: "He did so because he was only human. The white man offered him material goods—iron and woolens and gewgaws and alcohol —which he could not resist. These riches, which is what they were, gave his life an expanded dimension it had never known before. No power on earth could keep him from getting these things by raid or trade, once he had been exposed to them. To ask him to have refrained from making his material life fuller and richer is to ask him for far more than we ever have asked of ourselves." Hutchinson had identified the ecological Indian's Achilles' heel.

Hutchinson's response is essentially that of most other ethnohistorians who have pondered the Indian's role in the fur trade—the most notorious and unequivocal case of resource abuse by native North Americans. There can be no denying that the native hunter was the principal agent of wildlife destruction in most theaters of the fur trade, particularly in Canada where whites operated mainly as brokers rather than as hunters and trappers. In Canada, where the evidence against the Indian is most damaging, there were, in fact, mitigating circumstances that make the Subarctic Indian's motive in wildlife extermination considerably less crass than scholars such as Hutchinson have conceded. Without denying the essential validity of Hutchinson's statement that Indians were initially impressed with the items proffered them by Europeans—and at the risk of being accused of ennobling the "savage" once more—I would give a somewhat different, localized version of what happened when all those marvelous items of Old World origin first reached the native hunters of eastern Canada.

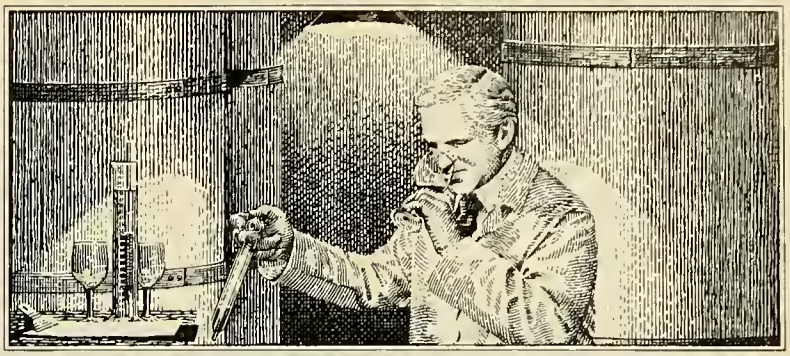
Put succinctly, the fur trade throughout eastern Canada was a paradox. Native hunters felt a sense of spiritual kinship with major game animals, including those sought for their pelts—a relationship tempered by genuine awe and fear of these powerful animal beings and their spiritual wardens, or game bosses. Historic evidence seems to corroborate the modern ethnographer's claim that Subarctic Indians have traditionally been obsessed by the responsibilities of the hunter and the hunted toward one another. Included among these responsibilities has been the understanding between man and animal that game can be harvested only in modest quantities. Animals have always considered immoderate slaughter to be presumptuous. According to present-day tribesmen and their early historic ancestors, game animals voluntarily surrender themselves to be slain by the needy hunter. The injunction against overkill could not be circumvented by disposing of the animal remains in a manner pleasing to the slain beast, after which regeneration would normally occur. Such procedures worked only when

the hunter restricted his take to a reasonable quota agreed upon between his spirit being and that of the animal he yearned for, and communicated with, in his dreaming, singing, drumming, and sweating —all of this prior to the actual hunt.

Subarctic hunters also considered animals to be persons with whom humans could talk and enjoy other forms of social intercourse, including the right to harvest these "animal persons" on a limited basis. In sum, man and animal have traditionally had a relationship of mutual courtesy: intelligent animal beings and intelligent human beings had contracted long ago not to abuse one another. Animals took offense not only when they were slaughtered in excessive numbers but also when they were subjected to other forms of disrespect: when humans failed to address them by the proper titles of endearment or when their remains were defiled by being thrown to the dogs or when their flesh was consumed by menstruating women. Humans, in their turn, were offended when animals refused to be taken in their traps or otherwise eluded the famished hunter and his family. Whenever one side transgressed the bounds of propriety the other side unleashed its arsenal of weapons to chastise the offenders and bring them back into line. For their part, animals could punish humans by fleeing their hunting areas, rendering their weapons impotent, or afflicting them with disease.

The paradox emerges in the early records, which describe how Canadian Indians hunted fur bearers and other mammals with abandon. One would think that their hunting ethic would have precluded the orgiastic destruction of wildlife.

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But that ethic was apparently suspended during the heyday of the Canadian fur trade. The Indian described in these records is peculiarly hostile toward animals: he hunts the beaver and other large game with a vengeance; his mood is vindictive. Furthermore, he has clearly lost touch with much of the spirit world that sustained him prior to the coming of Europeans. Sometime in the early contact period, nature—the universe—seems to have become inarticulate and the dialogue between human persons and animal persons ceased, at least temporarily. The French surgeon-botanist Sieur de Dièreville conveyed in 1708 the essence of this sentiment in some wretched verse on the art of beaver hunting:

They [the natives] take precautions
in regard to all
The varied needs of life. The Indian
race,
Well qualified to judge the point,
because
Of its familiarity with all their arts,
Believe that they [beaver] have been
endowed
With an abounding genius, and hold
too
It is pure malice that they do not talk.

Or as the Recollet priest Chrestien Le Clercq explained it in 1691, the Micmac Indians who still insisted that the beaver had "sense" and formed a "separate nation," maintained that they "would cease to make war upon these animals if these would speak, howsoever lit-

Isham's Observations and Notes, 1743–1749; The Champlain Society



(1) A Beaver house; (2) the thickness made of stone, mudd, & wood &c.; (3) where the Beaver Lyes within the house; (4) when the Beaver are Disturb'd, or hear a noise they make into the water, from 3 and 6; (5) where their food Lyes; (6) the half Beaver or small Beaver Lyes; (7) a Indian breaking the house op'n with a Chissel, tied to a Long stick; (8) the Beaver making out of the house hearing a noise and makes to the Vaults; (9) netts sett in the Creek with a string and a stick at the End to catch the Beaver as they come out of the house; (10) a Indian sitting by a fire watching a Nett, with a stick by him to Kill them as he hauls them out; (11) Dam's made by the Beaver, that the water shou'd not Run too fast upon them; (12) Vaults the Beaver makes into when Disturb'd. out of the house, they Run abt. 12 or 14 foot in Land (i.e.) and abt. 2 foot under the Ground, a foot Square & a foot Deep; (13) a Beaver hawling a tree by the teeth into the water; (14) a stop'age made by Inds. with stakes to Keep the Beaver from going into the River; (15) a Beaver cutting a tree Downe with his teeth, wch. Lean's over the water; (16) the stump where cutt Down; (17) the tail of a beaver; (18) the Castor under wch. Lyes the oyly stones or 2 bladder's; (19) the penis and stones; (20) the Gutts or Interials; (21) the heart & Liver; (22) the Lights; (23) the fore feet; (24) Inds. tent in the woods; (25) a Indian going a hunting; (26) willows on the Edge of the creek; (27) a flock of partridges; (28) thick woods; (29) a stick Lying by the Indn. to Kill Beaver &c.; (30) the Creek which Run's into the Large Rivers &c.

tle, in order that they might learn whether the Beavers are among their friends or their enemies." Near the turn of the nineteenth century, surveyor David Thompson and fur trader Alexander Henry, the Elder, encountered Cree and Ojibwa in southern Manitoba and the upper Great Lakes region who referred to some sort of conspiracy of animals against mankind for which the beaver, at any rate, were "now all to be destroyed." Together with these cryptic remarks on the overt antagonism between man and animal, there is considerable explicit and inferential evidence proving that the man–animal relationship had gone sour.

Indian hunters now tracked game remorselessly; no thought was given to the animals' welfare as the beaver and other fur bearers were hounded to near extinction in parts of the north woods. What made the Indian apostatize? I believe the answer lies in the devastating impact of diseases on these people.

The early records contain frequent references to eastern Canadian Indians, in common with native Americans throughout the hemisphere, being decimated by a variety of Old World contagions, most significantly, smallpox, influenza, and plague. Folkloric and circumstantial evidence place the arrival of these diseases well before the date of first recorded European contact. In all likelihood coastal Indians were exposed to deadly bacteria and viruses carried by Bristol, Norman, Basque, and other European fishermen who were working the various banks off the Canadian Maritimes some years before the Genoan-born merchant John Cabot "discovered" and officially took possession of the area for the English king, Henry VII, in 1497. Transmitted by infected natives, the diseases rolled inland. And the death rate was appalling. In the early seventeenth century the Jesuit Pierre Biard recorded that the Micmacs "are astonished and often complain that . . . they are dying fast, and the population is thinning out." Similar testimonials occur throughout the *Jesuit Relations* and other early records of New France. The victims had never encountered these diseases until the Europeans arrived, and the high mortality was due to the natives' lack of adequate immunological protection.

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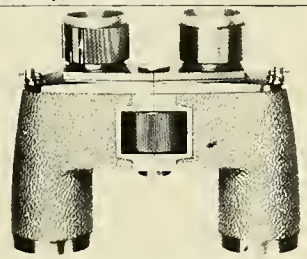
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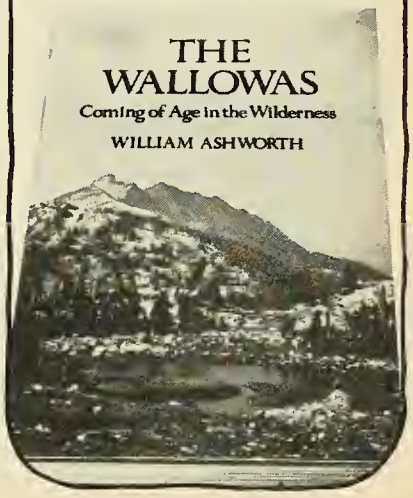
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Eastern Canadian Indians have always interpreted major illness as punishment for some sort of transgression, generally meted out by offended wildlife spirits. Fitting the ethnographic and historic records together, I conjecture that prior to sustained contact with whites, who subsequently would be correctly suspected of being responsible for this calamity, the eastern Canadian aborigine followed conventional logic and blamed these mysterious, devastating epidemics on angered wildlife. Here was the "conspiracy" of animal against man alluded to by Cree and Ojibwa sources: wildlife had decided, for some obscure reason, to direct their most potent weapon against man, who now felt himself imperiled by their terrible wrath. Wildlife had broken the compact of mutual courtesy. The dialogue between man and animal became acrimonious and then simply ended for many individuals.

Such was the emotion-charged setting that European traders and missionaries penetrated in the seventeenth and eighteenth centuries. Gently urging the Indians to furnish furs for the European market and renounce their "superstitions" for the sake of the Gospel, the Europeans could not have found a more receptive audience. The Indians were predisposed to respond positively to both requests. Their spiritual complex a shambles, they now turned on their former colleagues, the game, with a vengeance and an improved hunting technology. The Indians were, as some Micmac aptly phrased it, literally making war upon the beaver.

The Canadian Indian may well have been a conservationist of animal resources as long as he considered them articulate and congenial beings—a hunting ethic that has been revived in this century by Indians in many parts of Canada. The message for those environmentalists who have looked to the Indian for spiritual inspiration, however, is not encouraging. The northern hunter conserved animals only when the two engaged in courteous dialogue. It is unlikely that Western societies will ever duplicate this particular, functionally conservationist vision of the universe. Nature, it seems to me, will be forever deaf and dumb in the presence of Judeo-Christian societies. □

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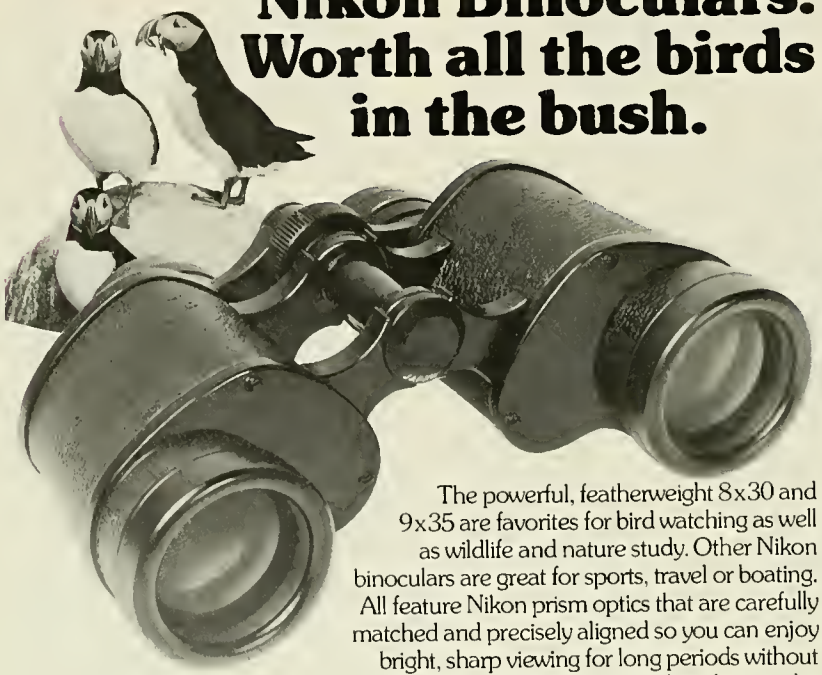
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Two-story cabin in North Carolina

additional log buildings that served as barns, corncribs, or storage sheds, and often the entire complex of buildings was surrounded by rail fencing. The greatest advantage of the log house, aside from the availability of the building material, was that with the help of friends and neighbors an adequate home could be built in a day or two. And for people moving into previously unsettled areas, immediate shelter was a matter of survival.



Cabin with limestone-base chimney



John O Ellis

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Additional Reading

Petra (p. 42)

Iain Browning uses many pictures, diagrams, maps, and tables in his study of the tombs, artifacts, ruins, and writings of the Nabataeans: *Petra* (Park Ridge: Noyes Press, 1973). The book reviews the origins and history of Nabataea, discusses the historians of Petra, and describes what the site is like today. A massive archeological treatise, *Petra: Its History and Monuments* (London: Country Life, 1925), by Sir Alexander Kennedy, contains more than 200 pictures reproduced in photogravure. In *Deities and Dolphins: The Story of the Nabataeans* (New York: Farrar, Straus, and Giroux, Inc., 1965), Nelson Glueck studies the Nabataeans' relationship to Arabia and the Fertile Crescent and to the Mediterranean littoral. His book, based on excavations at Khirbet Tannur, covers the history, economy, art, architecture, language, and religion of the Nabataeans and includes an extensive bibliography, plans, and maps. Philip C. Hammond has written many books and articles (with bibliographies) on Petra and the Nabataeans. Among them are *The Nabataeans: Their History, Culture and Archaeology,* volume 37 of "Studies in Mediterranean Archaeology" (Lund: Åstrøms, 1973), "Petra" (*Biblical Archaeologist,* vol. 23, 1960, pp. 29–32), and "Rose-Red City of Petra" (*Natural History,* February 1964, pp. 15–25).



Gail Rubin

Terns (p. 54)

When Michael Harwood spent a summer doing bird research at the American Museum of Natural History's research station on Great Gull Island he kept a journal, which grew into *The View from Great Gull* (New York: E. P. Dutton and Co., Inc., 1976). *Spirit of Survival: A Natural and Personal History of Terns,* by John Hay, president of the Cape Cod Museum of Natural History, covers the nesting, breeding, courtship, and specialized habits of terns and discusses tern survival. A basic book for serious students is Arthur C. Bent's *Life Histories of North American Gulls and Terns* (New York: Dover Publications, Inc., 1921). *Natural History* recently had two articles on terns: "Late-blooming Terns," by Paul A. Buckley and Francine G. Buckley (April 1976, pp. 46–55) and "The Early Warning of the Terns," by Helen Hays and Robert W. Risebrough (November 1971, pp. 38–47). "Pollutant Concentrations in Abnormal Young Terns from Long Island Sound," by Helen Hays and Robert W. Risebrough, appeared in the January 1972 issue of *The Auk.*

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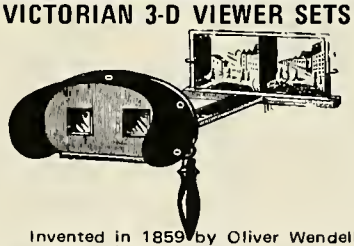
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Luis Villota



Swamp Dwellers of Bahia (p. 62)

Raft Fishermen: Tradition and Change in the Brazilian Peasant Economy (Bloomington: Indiana University Press, 1970) and *The Brazilian Peasantry* (New York: Columbia University Press, 1975) are two works by Shepard Forman that grew out of the author's travels throughout Brazil. The latter discusses the problems of "masters and slaves," starvation, politics, religion, and social protest in Bahia. In *Sharecroppers of the Sertao: Economics and Dependence on a Brazilian Plantation* (Stanford: Stanford University Press, 1971), Allen W. Johnson regards the economic life of resident plantation laborers in the state of Ceará, Brazil, as an ecological adaptation. In *Obstacles to Development in Latin America* (Garden City: Doubleday and Company, Inc., 1970), economist Celso Furtado uses Brazil as a particular case to direct the reader's attention to external factors that perpetuate underdevelopment. Josué de Castro, author of *Death in the Northeast* (New York: Random House, Inc., 1966), describes his book as "a sociological study by one who is committed to a partisan and progressive point of view." Two articles on lunar-tide fishing systems are "The Lunar-tide Fishing Cycle in Northeastern Brazil" (*Ethnology*, 1974, pp. 379–92) and "Traditional Time Reckoning and Resource Utilization" (*Micronesica*, December 1976, pp. 211–46). *Economic Development and Cultural Change* published "The Population Question in Northeastern Brazil: Its Economic and Ideological Dimensions," by Herman E. Daly, July 1970, pp. 536–74.

Plant Cells (p. 74)

Two articles on the structure of land plants have appeared in *Scientific American:* "Roots," by Emanuel Epstein (May 1973, pp. 48–58), and "The Mechanical Design of Trees," by Thomas A. McMahon (July 1975, pp. 92–102). *Trees: Structure and Function,* by Martin H. Zimmermann and Claud L. Brown (New York: Springer-Verlag Inc., 1975), delves more deeply into the subject. "The Adaptive Characteristics of Desert Plants," by Otto T. Solbrig and Gordon H. Orians (*American Scientist,* July-August 1977, pp. 412–21), discusses the economics of the photosynthesis of evergreen shrubs, succulents, drought evaders, and phreatophytes and their ecological distribution in the desert.

Indians and the Fur Trade (p. 92)

The special relationship of the Montagnais-Naskapi of Canada to their spiritual world; their use of divination, magic, medicine, and charms; and their concept of the soul and the universe are the subjects of Frank G. Speck's *Naskapi:*

The Savage Hunters of the Labrador Peninsula (Norman: University of Oklahoma Press, 1977). *Indians in the Fur Trade: Their Role as Trappers, Hunters, and Middlemen in the Lands Southwest of Hudson Bay, 1600–1860* (Toronto: University of Toronto Press, 1974), by Arthur J. Ray, concentrates on the effects of the fur trade on native Americans. Much of the information was gathered from the Hudson's Bay Company's microfilm collection. In *The Fur Trade in Canada: An Introduction to Canadian Economic History,* by Harold Innis (Toronto: University of Toronto Press, 1930, rev. ed. 1970), the fur trade is described as the primary cause for the expansion of settlement in Canada. Innis traveled in the fur trade territories and researched original documents and records. *Exploring the Northwest Territory: Sir Alexander Mackenzie's Journal of a Voyage by Bark Canoe from Lake Athabasca to the Pacific Ocean in the Summer of 1789* (Norman: University of Oklahoma Press, 1967) was recorded by the director of the Northwest Fur Company while exploring what came to be known as the Mackenzie River System. Full of detailed descriptions of the customs, dress, and habits of native Americans, the journal has a historical introduction by the editor, T. H. McDonald, and a bibliography. *Winner Take All: The Trans-Canada Canoe Trail,* by David Lavender (New York: McGraw-Hill Book Company, 1977), is the story of the struggle of the Hudson's Bay Company, the Northwest Company, Indians, French, and Scots to control the fur trade along the 4,000 miles of interlocking waterways that span the continent. *The Beaver,* journal of the Hudson's Bay Company, Winnipeg, Manitoba, is full of information on Canadian Indians. In 1965 it ran a series of articles, "The Story of the Canadian Fur Trade," in four issues, spring through winter. A standard reference for ethnologists is *The Indians of Canada,* by Diamond Jenness (Toronto: University of Toronto Press, 1963).

Katharine D'Agosta

ERRATUM: In "Blackouts and Births," page 26 of our April issue, we should have said that the New York City blackout began the evening of July 13, 1977, not July 14.

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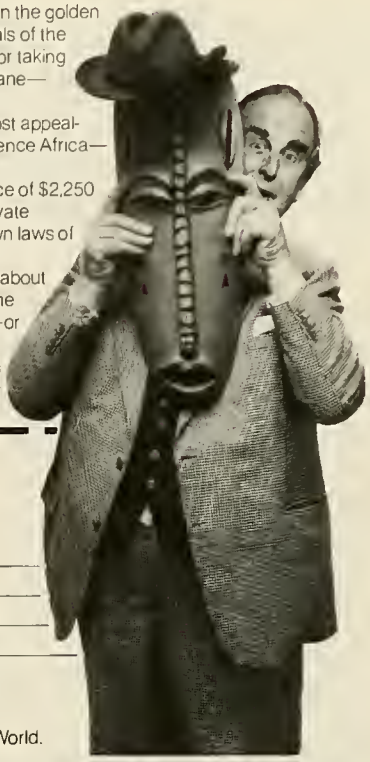
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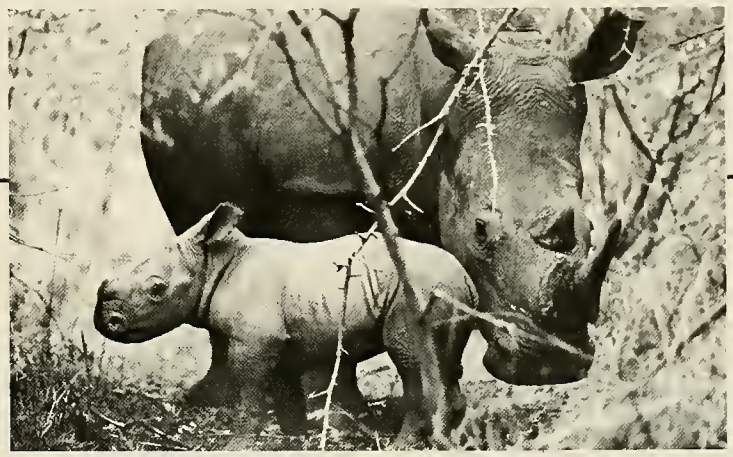


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At the Museum

Although most schools are on summer holiday, the Hayden Planetarium continues to buzz with excited children. Many have probably seen *Star Wars* and *Close Encounters of the Third Kind* at least twice, but are still captivated by the size, weight, and complexity (29,000 parts) of the Planetarium's projector. As the show begins, children cheer when the New York City skyline appears on the rim of the domed screen overhead. And while the projector turns and the night sky brightens on the dome, some children can be heard challenging others to spot a UFO (unidentified flying object).

Mark Chartrand, chairman of the Hayden Planetarium, has been listening, and he has written the new show, **UFOs and IFOs** (June 29 through November 20), with children and adults in mind. The Planetarium receives occasional phone calls reporting UFO sightings, and Chartrand says that according to the Gallup Poll, one American in ten has sighted a UFO. Since some of these people are bound to turn up in the Planetarium audience, the show will describe how UFOria came about, what sort of sightings people report, what can really appear in the sky.

Chartrand believes that most sightings are of familiar objects—planets, balloons, aircraft, reentering satellites, meteors, atmospheric illusions—seen under unfamiliar circumstances. IFOs (identified flying objects) are mistaken for UFOs because "today, many of us are isolated from the sky. If you live in a city, you can't even see it very well. And unlike our ancestors, we don't have to be aware of the moon's phases in order to sustain ourselves, to plant and harvest at the right times."

Eighteen years ago, psychoanalyst Carl Jung speculated that "the worldwide rumor about flying saucers" began as a psychological reaction to the possibility of space travel. He saw in UFOs "a golden opportunity to see how a legend is formed." The Planetarium show will re-create some legendary sightings, including one incident that occurred in the late 1940s, when pilots in an airplane over Alabama thought that they were being buzzed by a UFO. The object turned out to be a meteor passing over them.

Some historians pinpoint the birth of contemporary interest in UFOlogy as June 24, 1947, when a pilot in a private plane encountered nine disklike objects, "flying saucers," near Mount Rainier. Chartrand, however, says that reports of sightings go back thousands of years. One of the earliest may be recorded in the Old Testament, the Prophet Ezekiel's vision of four flying wheels with rims "full of eyes round about them. . . ."

Since film makers have been responsible for this year's excitement over UFOs, the Planetarium will, appropriately enough, be the setting for a summer lecture course on "The Universe of Science Fiction Film," to be held on five Tuesday evenings from July 11 to August 8. The moderator, Ben Bova, novelist and editor of *Analog*, will introduce each film and lead a general discussion after the showing. The debate will concentrate on ideas and problems raised in the films, not on film making technique. The program of six films includes two classics in the annals of spectacular special effects, *2001: A Space Odyssey* (1968) and *The Fantastic Voyage* (1966); in the latter a group of scientists reduced to the size of microbes journey through a man's body to remove inoperable cancer cells from his brain.

Two other films take the classic science fiction view of the scientist as an irresponsible meddler in dangerous matters. In *Dr. Cyclops* (1940), a mad, nearsighted scientist uses a chemical potion to reduce people and animals to puppet size. *The Invisible Man* (1933) is based on H.G. Wells's tale, in which a scientist experimenting with an Indian drug becomes both invisible and insane, setting out to rule the world as a frighteningly powerful invisible terrorist. Another film, *The Forbin Project* (1970), is based on D.F. Jones's novel, *Colossus*, in which scientists' inventions correct their makers' mistakes: a supercomputer in the Pentagon connects with another in the Kremlin, and the two enforce world peace. Probably the most provoking film on the agenda is *Invasion of the Body Snatchers* (1956), in which huge seedpods drain sleeping humans of their likenesses and minds, leaving zombielike replacements who intone chilling statements, such as "love, ambition, desire, faith—without them, life is so simple."

Film course sessions will start at 7:00 P.M. and end at about 10:30 P.M. Tuition is $30, and there will be no single admissions. For further information, call the Planetarium at (212) 873-1300, extension 300 or 206.

Other Events

Saturday, June 3, from 11:00 A.M. to 4:30 P.M. and Sunday, June 4, from noon to 4:30 P.M. the Museum will present a weekend Festival of Nature Films. There will be several speakers, including Kjell Sandved, who specializes in filming tiny beings. Sandved will present *Curious Creatures and Minimonsters* in the Museum auditorium at 3:00 P.M. on Sunday.

On four consecutive Wednesday evenings, June 7, 14, 21, and 28, "How Yukong Moved the Mountains," a series of films made in the People's Republic of China by Joris Ivens and Marceline Loridan, will be shown in the Museum auditorium at 7:00 P.M. The series concentrates on the everyday life of the mainland Chinese, and studies the city of Shanghai, rehearsals at the Peking circus and opera, and people at work—in stores, craft shops, fishing villages, and oil fields.

On June 17 and 18, from 1:00 to 4:30 P.M. the Museum will present a Japanese Weekend, featuring films, theater, and dance performances.

Unless otherwise noted, Museum events are free to Members and to those who have paid the Museum's discretionary admission fee.

Ann Marie Cunningham

SOMEHOW, SCOTCH BOTTLED ELSEWHERE ISN'T QUITE THE SAME.

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Incorporating Nature Magazine
Vol. LXXXVII, No. 7
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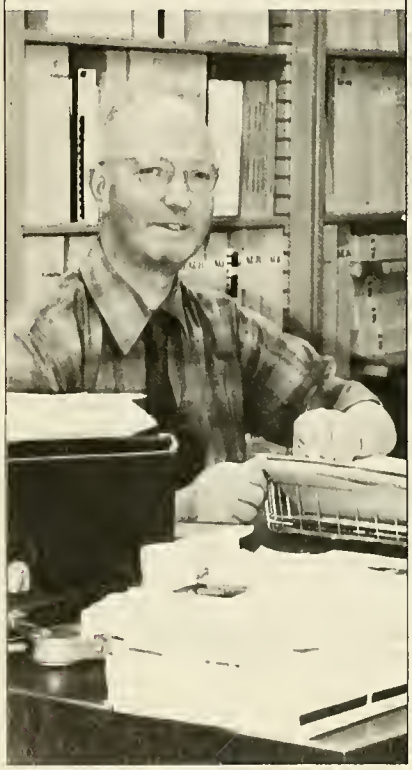
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Authors

English-born **Clifford H. Mortimer,** formerly director of the Scottish Marine Biological Association, has been a limnologist and director of the Center for Great Lakes Studies at the University of Wisconsin-Milwaukee since 1966. On his first visit to the Great Lakes region in 1953, Mortimer was intrigued by the "evidence of internal wave motions in temperature records of water intakes of cities bordering on the Great Lakes." His article in this special Great Lakes issue demonstrates his interest in the hydrodynamics of large lakes.





Eugene F. Stoermer writes: "I really enjoy the type of old-fashioned botanical exploration that terrestrial botanists did one hundred or more years ago and find the same sense of discovery is still available working on microscopic communities in the depths of the lakes." A research algologist at the University of Michigan's Great Lakes Research Division, Stoermer has taken extended research cruises on all the Great Lakes. In his work on freshwater algal communities, he views the lakes "as a vast, uncontrolled experiment that has been carried out over the past few decades. We are trying to reconstruct what has happened and determine the causes."

Born in Czechoslovakia, **Sergej Postupalsky** emigrated to the United States in 1952 and was a draftsman in the automotive industry for twelve years. Stimulated by reports of declines in bald eagle populations, he began doing ornithological fieldwork in 1960. Postupalsky has worked as a wildlife biologist for the U.S. Fish and Wildlife Service, the Canadian Wildlife Service, and the Michigan Department of Natural Resources and is now preparing his Ph.D. dissertation, on bald eagles and ospreys, at the University of Wisconsin.



On Photographing the Invisible

To the naked eye, it was a Swedish 80-ore postage stamp. A rarity, and very valuable.

The camera, however, told quite another story. The stamp was a counterfeit.

Faint traces of tampering that were hidden to the naked eye were revealed by the camera. Someone, somewhere, had ingeniously altered the stamp by chemically removing a surprint. The stamp was worthless.



To the naked eye (left), the stamp was genuine. To the camera (right), it was a counterfeit. Note the faint, dark traces of tampering now revealed in the upper section.

What manner of exotic camera was this that could "see" the invisible?

The lens: one of the 20 in the Hasselblad arsenal, the 105mm Zeiss UV-Sonnar f4.3. Designed for photography within the ultraviolet portion of the electromagnetic spectrum, its costly quartz elements can detect radiations that are unseeable by the human eye.

It has peered at objects in outer space, examined forgeries, laid bare the secrets of counterfeit money. Not a lens for everyone, obviously, but an indication of just how awesomely comprehensive the Hasselblad System is.

The camera: an otherwise perfectly standard Hasselblad 500C/M, normally fitted with an 80mm Zeiss Planar f2.8 multi-coated lens.

This is the basic model that allows you to tap into the vast Hasselblad System. It is one of the most bewilderingly versatile cameras the world has ever known. Yet so marvelously simple to operate that it often plays the part of the family snapshot camera.

A True System.

The Hasselblad System is a prodigious array of 4 cameras, 20 lenses, 8 viewfinders, 9 film magazines, and over 300 other accessories. Choose the right pieces, and your 500C/M would be equipped for sports, aerial, architectural, and fashion photography.

And portrait, landscape, medical, underwater, and news photography.

And wildlife, laboratory, industrial, and child photography.

And you would always have the right film in the camera at the right time. You can shift from color to black-and-white and back again to color—and resume shooting at precisely the right frame—by popping in the protective dark slide and switching film backs.

The Camera with Nine Backs.

There is a small button on the film back of every Hasselblad 500C/M. Slide it sideways with your thumb and the back will come away in your hand.

The standard back holds 12 exposures. Each frame of film is 2¼ inches square, *almost four times the area of a 35mm frame.* (See box, below right, for actual size.)

This is only the beginning. There are eight other backs available: Backs that let you change to a 6 x 4.5cm format...or a 4.5 x 4.5cm superslide format for showing in any 35mm projector. Backs that give you a choice of 1, 12, 16, 24, 70, or 500 exposures. A back that is a sheet-film adapter. Even two backs for Polaroid film, so you can check composition, lighting, and exposure ahead of time.

You begin to realize why eight out of ten top commercial photographers surveyed name Hasselblad as the medium-format camera used in their work.

Retained Value vs. Obsolescence.

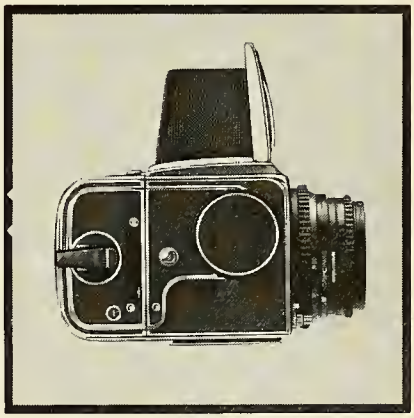
In an age when machines spew out cameras in the tens and hundreds of thousands, when flashy new models thrust last year's marvels into early obsolescence, Hasselblad goes its own way.

Planned obsolescence is taboo at Hasselblad. All but two of the accessories for the 500C/M will fit every Hasselblad made since 1957 (except the Super Wide C)...and will fit every future Hasselblad.

The greater part of a year is spent on building each camera, much of it crafted by hand. And fully one quarter of the work force devotes its time to nothing but quality control.

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Ronald L. Stuckey has successfully combined his interests in history and botany in many articles on the origins, changes, and geographical relationships of aquatic flowering flora. A professor of botany at Ohio State University, Stuckey conducts research during the summer at the Franz Theodore Stone Laboratory, Put-in-Bay, Ohio, where he collected the data used in his article in this issue. He also is studying the history of botanical exploration in the Ohio Valley from 1800 to 1850.



Author of the article on atmospheric pollution in the Great Lakes, **Jon I. Parker** is an ecologist in Argonne National Laboratory's Division of Environmental Impact Studies. Before undertaking his current fieldwork on Lake Michigan, Parker conducted research on trace element contamination in the aquatic ecosystems of Idaho's Lake Coeur d'Alene and on Massachusetts Bay.





Like many of the authors in this issue, **Steven A. Spigarelli** is deeply concerned about the environment of the Great Lakes, both as scientist and outdoorsman. An ecologist at the Radiological and Environmental Research Division at Argonne National Laboratory in Illinois, Spigarelli is a fisherman, hunter, and camper on vacations and weekends. He writes, "I am convinced that natural habitats and wilderness areas play a role in human social development. I am also concerned about the future of basic ecological research. The present trend is toward narrow, applied, site-specific studies that contribute very little to an understanding of ecosystem processes and functions."

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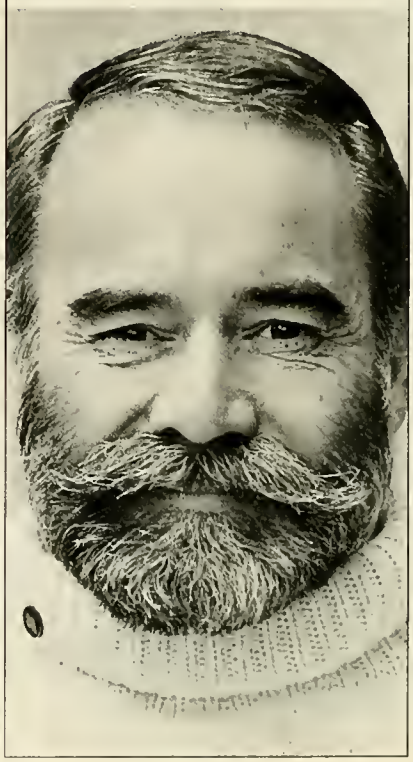
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Stanford H. Smith was a fish biologist with the U.S. Fish and Wildlife Service for twenty-eight years and is widely respected as an authority on the history of fish communities in the Great Lakes. Smith earned his Ph.D. degree from the University of Michigan, where he is now adjunct professor of natural resources.



"I became interested in the story of the decline of the old-time fishermen through my long association with commercial fishermen on the Great Lakes," writes **Russell McKee**. A former newspaper reporter, McKee is now the editor of *Michigan Natural Resources*, the bimonthly magazine of the Michigan Department of Natural Resources.





Director of the Environmental Protection Agency's Large Lakes Research Station at Grosse Ile, Michigan, **Wayland R. Swain** is another scientist who is able to combine his avocations—diving, fishing, and boating—with his vocation—aquatic biology. "My most recent study was a survey of contaminants in fish at the mouths of all streams entering Lake Superior," he writes. "The crew averaged five to six hours a day underwater. Since the mean water temperature was 43°F, I suffered considerable verbal abuse, particularly such comments as 'Cousteau doesn't make his people do this kind of thing.' The photo was taken by my son John, who served as diving tender on this 45-day trip."

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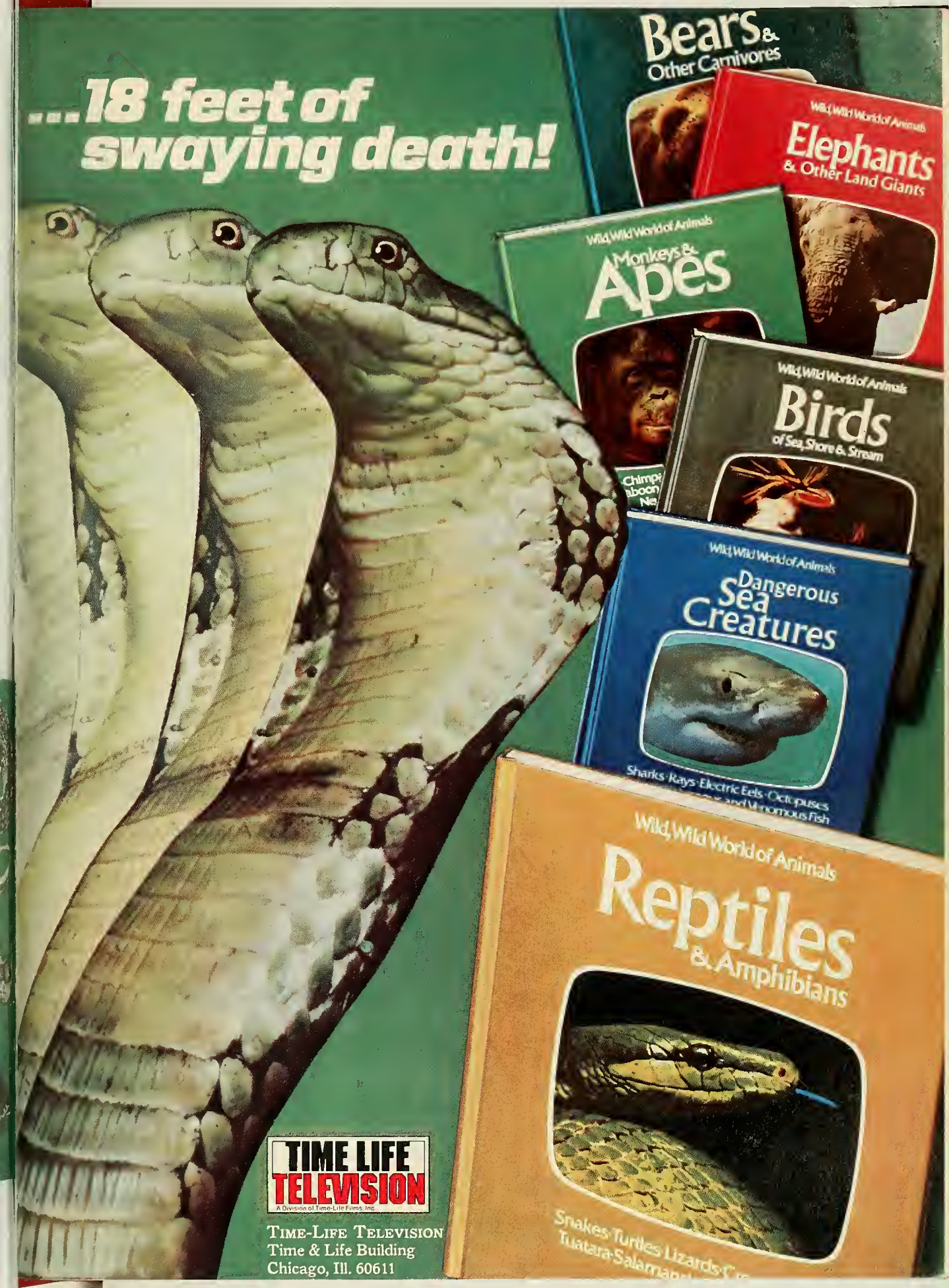
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The Great Scablands Debate

How could so vast an area of eastern Washington change so much in so little time?

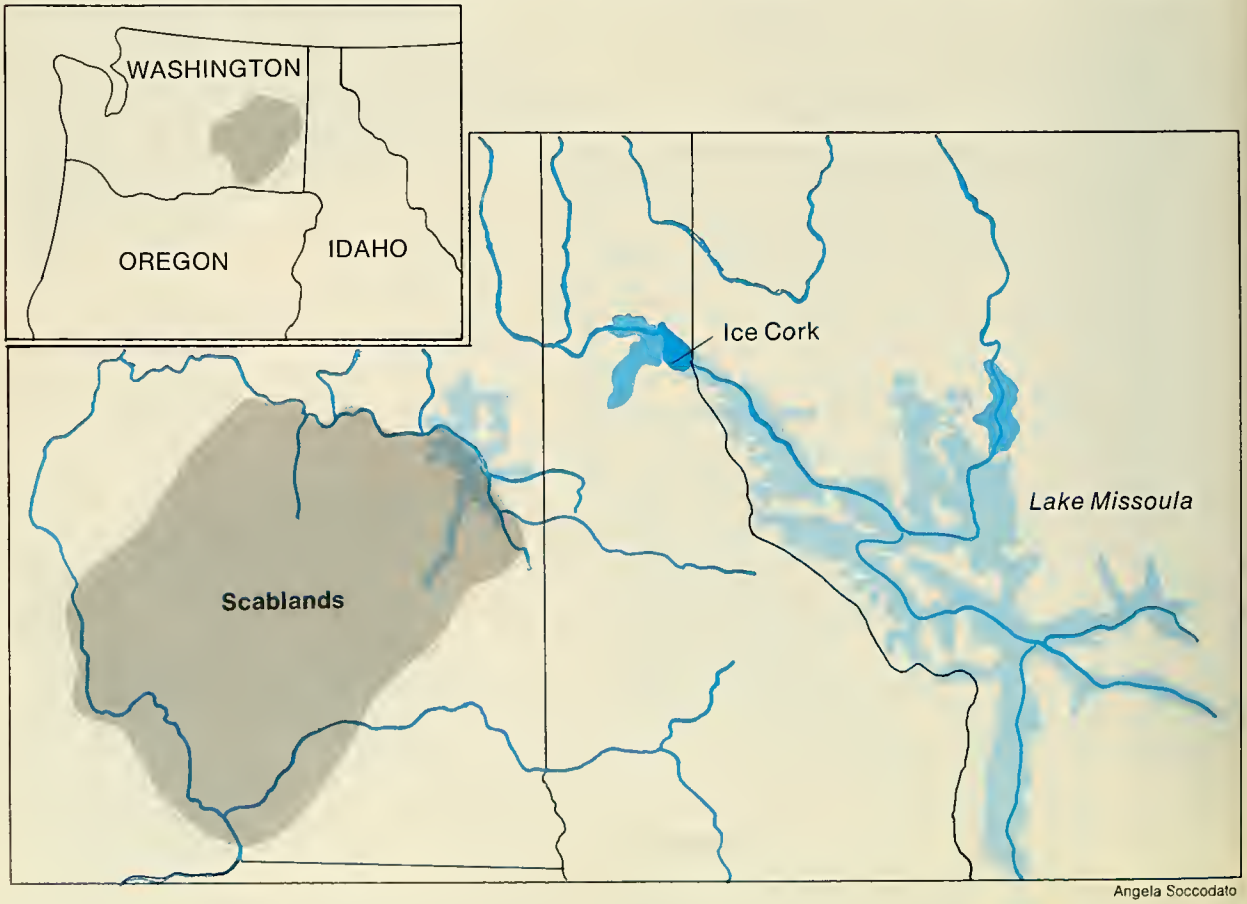
The introductory paragraphs of popular guidebooks usually tout prevailing orthodoxy in its purest form—dogma unadulterated by the "howevers" of professional writing. Consider the following from our National Park Service's auto tour of Arches National Park:

> The world and all it contains is in a continuous process of change. Most of the changes in our world are very tiny and so escape our notice. They are real, however, and over an immense span of time their combined effect is to bring about great change. If you stand at the base of a canyon wall and rub your hand on the sandstone, hundreds of grains of sand are dislodged. It seems like an insignificant change, but that's how the canyon was formed. Various forces have dislodged and carried away grains of sand. Sometimes the process is "very fast" (as when you rub the sandstone) but most of the time it is much slower. If you allow sufficient time, you can tear down a mountain or create a canyon—a few grains at a time.

As the primary lesson of geology, this pamphlet proclaims that big results arise as the accumulated effect of tiny changes. Time, geology's inexhaustible resource, performs all the miracles.

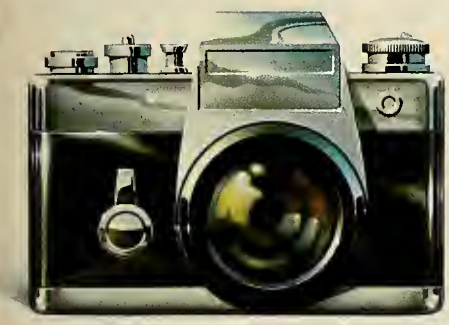
Yet, when the pamphlet turns to details, we encounter a different scenario for erosion in Arches. We learn that a balanced rock known as "Chip Off the Old Block" fell during the winter of 1975–76. Before and after photographs of the magnificent Skyline Arch receive the following commentary: "It remained thus for as long as man knew the arch, until, late in 1940, the block of stone fell, and Skyline was suddenly twice its former size." The arches form by sudden, intermittent collapse and toppling, not by imperceptible removal of sand grains. Yet gradualist orthodoxy is so entrenched that the authors of this pamphlet failed to note the inconsistency between their own factual account and the stated theory of their introduction.

I have questioned the gradualist



Angela Soccodato

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orthodoxy before in this column (May and June–July 1977), in general and biological terms. I have argued that gradualism is a culturally conditioned prejudice, not a fact of nature, and I have made a plea for pluralism in concepts of rate. Punctuational change is at least as important as imperceptible accumulation.

In this column, I tell a local, geologic story. But it conveys the same message—that dogmas play their worst role when they lead scientists to reject beforehand a counterclaim that could be tested in nature.

Flow basalts of volcanic origin blanket most of eastern Washington. These basalts are often covered by a thick layer of loess, a fine-grained, loosely packed sediment blown in by winds during the ice ages. In the area between Spokane and the Snake and Columbia rivers to the south and west, many spectacular, elongate, subparallel channelways are gouged through the loess and deeply into the hard basalt itself. These coulees, to use the local name, must have been conduits for glacial meltwaters, for they run down gradient from an area near the southern extent of the last glacier into the two major rivers of eastern Washington. The channeled scablands—as geologists designate the entire area—are puzzling as well as awesome, and for several reasons:

1. The channels connect across tall divides that once separated them. Since the channels are hundreds of feet deep, this extensive anastomosis indicates that a prodigious amount of water must once have flowed over the divide.
2. As another item favoring channels filled to the brim with water, the sides of the coulees contain many hanging valleys where tributaries enter the main channels. (A hanging valley is a tributary channel that enters a main channel high above the main channel's modern stream bed.)
3. The hard basalt of the coulees is deeply gouged and scoured. This pattern of erosion does not look like the work of a gentle river in the gradualist mode.
4. The coulees often contain a number of high-standing hills composed of loess that has not been stripped away. These are arranged as if they were once islands in a gigantic braided stream.
5. The coulees contain discontinuous deposits of basaltic stream gravel, often composed of rock foreign to the local area.

Just after World War I, Chicago geologist J Harlen Bretz advanced an unorthodox hypothesis to account for this unusual topography (yes, that's J without a period, and don't ever let one slip in, for his wrath can be terrible). He argued that the channeled scablands had been formed all at once by a single, gigantic flood of glacial meltwater. This local catastrophe filled the coulees, cut through hundreds of feet of loess and basalt, and then receded in a matter of days. He ended his major work of 1923 with these words:

> Fully 3,000 square miles of the Columbia Plateau were swept by the glacial flood, and the loess and silt cover removed. More than 2,000 square miles of this area were left as bare, eroded rock-cut channel floors, now the scablands, and nearly 1,000 square miles carry gravel deposits derived from the eroded basalt. It *was* a debacle which swept the Columbia Plateau.

Bretz's hypothesis became a minor *cause célèbre* within geologic circles. Bretz's stout and lonely defense of his catastrophic hypothesis won some grudging admiration, but virtually no support at first. The "establishment," as represented by the United States Geological Survey, closed ranks in opposition. They had nothing better to propose, and they did admit the peculiar character of scabland topography. But they held firm to the dogma that catastrophic causes must never be invoked so long as any gradualist alternative existed. Instead of testing Bretz's flood on its own merits, they rejected it on general principles.

On January 12, 1927, Bretz bearded the lion in its lair and presented his views at the Cosmos Club, in Washington, D.C., before an assembled group of scientists, many from the Geological Survey. The published discussion clearly indicates that a priori gradualism formed the basis for Bretz's glacial reception. I include typical comments from all detractors.

W. C. Alden admitted "it is not easy for one, like myself, who has never examined this plateau to

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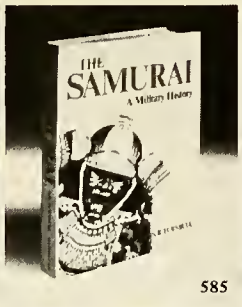
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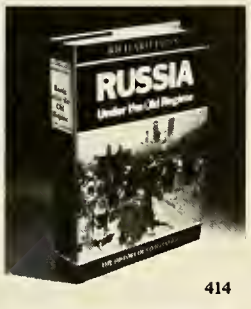
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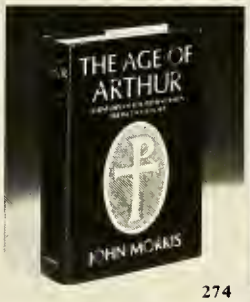
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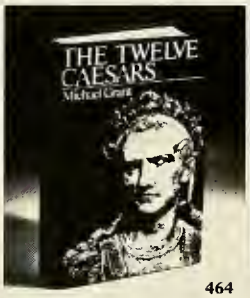
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supply offhand an alternative explanation of the phenomena." Nonetheless, undaunted, he continued: "The main difficulties seem to be: (1) The idea that all the channels must have been developed simultaneously in a very short time; and (2) the tremendous amount of water that he postulates. . . . The problem would be easier if less water was required and if longer time and repeated floods could be allotted to do the work."

James Gilluly, this century's chief apostle of geologic gradualism, ended a long comment by noting "that the actual floods involved at any given time were of the order of magnitude of the present Columbia's or at most a few times as large, seems by no means excluded by any evidence as yet presented."

E. T. McKnight offered a gradualist alternative for the gravels: "This writer believes them to be the normal channel deposits of the Columbia during its eastward shift over the area in preglacial, glacial, and postglacial times."

G. R. Mansfield doubted that "so much work could be done on basalt in so short a time." He also proposed a calmer explanation: "The scablands seem to me better explained as the effects of persistent ponding and overflow of marginal glacial waters, which changed their position or their places of outlet from time to time through a somewhat protracted period."

Finally, O. E. Meinzer admitted that "the erosion features of the region are so large and bizarre that they defy description." They did not, however, defy gradualist explanation: "I believe the existing features can be explained by assuming normal stream work of the ancient Columbia River." Then, more baldly than most of his colleagues, he proclaimed his faith: "Before a theory that requires a seemingly impossible quantity of water is fully accepted, every effort should be made to account for the existing features without employing so violent an assumption."

The story has a happy ending, at least from my point of view, for Bretz was delivered from the lion's lair by later evidence. Bretz's hypothesis has prevailed, and virtually all geologists now believe that catastrophic floods cut the channeled scablands. Bretz had found no adequate source for his floodwaters. He knew that the glaciers had advanced as far as Spokane, but neither he nor anyone else could imagine a reasonable way to melt so much water so rapidly. Indeed, we still have no mechanism for such an episodic melting.

The solution came from another direction. Geologists found evidence for an enormous, ice-dammed glacial lake in western Montana. This lake emptied catastrophically when the glacier retreated and the dam broke. The spillway for its waters leads right into the channeled scablands.

Bretz had presented no really direct evidence for deep, surging water. Gouging might have proceeded sequentially, rather than all at once; anastomosis and hanging valleys might reflect filled coulees with gentle, rather than raging, flow. But when the first good aerial photographs of the scablands were taken, geologists noticed that several areas on the coulee floors are covered with giant stream bed ripples, up to 22 feet high and 425 feet long. Bretz, like an ant on a Yale bladderball, had been working on the wrong scale. He had been walking over the ripples for decades but had been too close to see them. They are, he wrote quite correctly, "difficult to identify at ground level under a cover of sagebrush." Observations can only be made at appropriate scales.

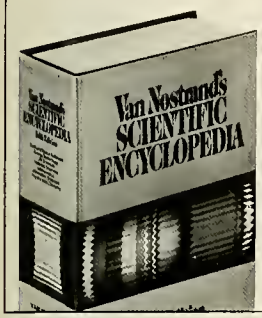
Hydraulic engineers can infer the character of flow from the size and shape of ripples on a stream bed. V. R. Baker estimates a maximum discharge of 752,000 cubic feet per second in the scabland flow channels. Such a flood could have moved 36-foot boulders.

I could end here with a cardboard version of the story much to my liking: Perceptive hero suppressed by blinded dogmatists stands firm, expresses his allegiance to fact over received opinion, and eventually prevails by patient persuasion and overwhelming documentation. The outline of this tale is surely valid: gradualist bias *did* lead to an out-of-hand rejection of Bretz's catastrophic hypothesis, and Bretz (apparently) was right. But, as I read through the original papers, I realized that this good guy–bad guy scenario must yield to a more complex version. Bretz's opponents were not benighted dogmatists.

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They did have a priori preferences, but they also had good reasons to doubt catastrophic flooding based on Bretz's original arguments. Moreover, Bretz's style of scientific inquiry virtually guaranteed that he would not triumph with his initial data.

Bretz proceeded in the classic tradition of strict empiricism. He felt that adventurous hypotheses could only be established by long and patient collecting of information in the field. He eschewed theoretical discussion and worried little about the valid conceptual problem that so bothered his adversaries: Where could so much water come from so suddenly?

Bretz tried to establish his hypothesis by toting up evidence of erosion in the field, piece by patient piece. He seemed singularly uninterested in finding the missing item —a source for the water—that would render his story coherent. For this attempt might involve speculation without direct evidence, and Bretz relied only upon fact. When Gilluly challenged him on the absence of a source for the water, Bretz simply replied: "I believe that my interpretation of channeled scabland should stand or fall on the scabland phenomena themselves."

But why should an opponent be converted by such an incomplete theory? Bretz believed that the southern end of the glacier had melted precipitously, and no scientist could imagine a way to melt ice so quickly. (Bretz tentatively suggested volcanic activity under the ice, but quickly abandoned the theory when Gilluly attacked.) Bretz stayed in the scablands, while the answer sat in western Montana. Glacial Lake Missoula had been in the literature since the 1880s, but Bretz did not make the connection—he was working in other ways. His opponents were right. We still do not know a way to melt so much ice so quickly. But the premise shared by all participants was wrong: the source of the water was water.

Events that "cannot happen" according to received wisdom rarely gain respectability by a simple accumulation of evidence for their occurrence: they require a mechanism to explain how they *can* happen. Early supporters of continental drift ran into the same difficulty that Bretz encountered. Their evidence of faunal and lithological similarities between continents now widely separated strikes us today as overwhelming, but it failed in their time because no reasonable mechanism had been proposed for moving continents. The theory of plate tectonics has since provided a mechanism and established the idea of continental drift.

Moreover, Bretz's opponents did not rest their case entirely on the unorthodox character of Bretz's hypothesis. They also marshaled some specific facts on their side, and they were partly right. Bretz originally insisted upon a single flood, while his opponents cited much evidence to show that the scablands had not formed all at once. We now know that Lake Missoula formed and re-formed several times as the glacial margin fluctuated. In his latest work, Bretz called for eight separate episodes of catastrophic flooding. Bretz's opponents were wrong in inferring gradual change from the evidence of temporal spread: catastrophic episodes can be separated by long periods of quiescence. But Bretz was also wrong in attributing the formation of the scablands to a single flood.

I prefer heroes of flesh, blood, and fallibility, not of tinseled cardboard. Bretz is inscribed on my ledger because he stood against a firm, highly restrictive dogma that never had made any sense: the emperor had been naked for a century. Charles Lyell, the godfather of geologic gradualism, had pulled a fast one in establishing the doctrine of imperceptible change (see my column of February 1975). He had argued, quite rightly, that geologists must invoke the invariance (uniformity) of natural law through time in order to study the past scientifically. He then applied the same term—uniformity—to an empirical claim about rates of processes, arguing that change must be slow, steady, and gradual, and that big results can only arise as the accumulation of small changes.

But the uniformity of law does not preclude *natural* catastrophes, particularly on a local scale. Perhaps some invariant laws operate to produce infrequent episodes of sudden, profound change. Bretz may not have cared for this brand of philosophical waffling. He probably would brand it as vacuous nonsense preached by an urban desk man. But he had the independence and gumption to live by a grand old slogan from Horace, often espoused by science but not often followed: *Nullius addictus jurare in verba magistri*, "I am not bound over to swear allegiance to any master."

My tale ends with two happy postscripts. First, Bretz's hypothesis that channeled scabland reflects the action of catastrophic flooding has been fruitful far beyond Bretz's local area. Scablands have been found in association with other western lakes, most notably Lake Bonneville, the large ancestor of a little puddle in comparison—Great Salt Lake, Utah. Other applications have ranged about as far as they can go. Bretz has become the darling of planetary geologists who find in the channelways of Mars a set of features best interpreted by Bretz's style of catastrophic flooding.

Second, Bretz did not share the fate of Alfred Wegener, dead on the Greenland ice while his theory of continental drift lay in limbo, or of Schubert, buried in a pauper's grave so long before Fischer-Dieskau could sing his songs to an adoring world. J Harlen Bretz presented his hypothesis sixty years ago, but he has lived to enjoy his vindication. He is now well into his nineties, feisty as ever and justly pleased with himself. In 1969, he published a forty-page paper summarizing a half century of controversy about the channeled scablands of eastern Washington. He closed with this statement:

> The International Association for Quaternary Research held its 1965 meeting in the United States. Among the many field excursions it organized was one in the northern Rockies and the Columbia Plateau in Washington. . . . The party . . . traversed the full length of the Grand Coulee, part of the Quincy basin and much of the Palouse-Snake scabland divide, and the great flood gravel deposits in the Snake Canyon. The writer, unable to attend, received the next day a telegram of "greetings and salutations" which closed with the sentence, "We are now all catastrophists."

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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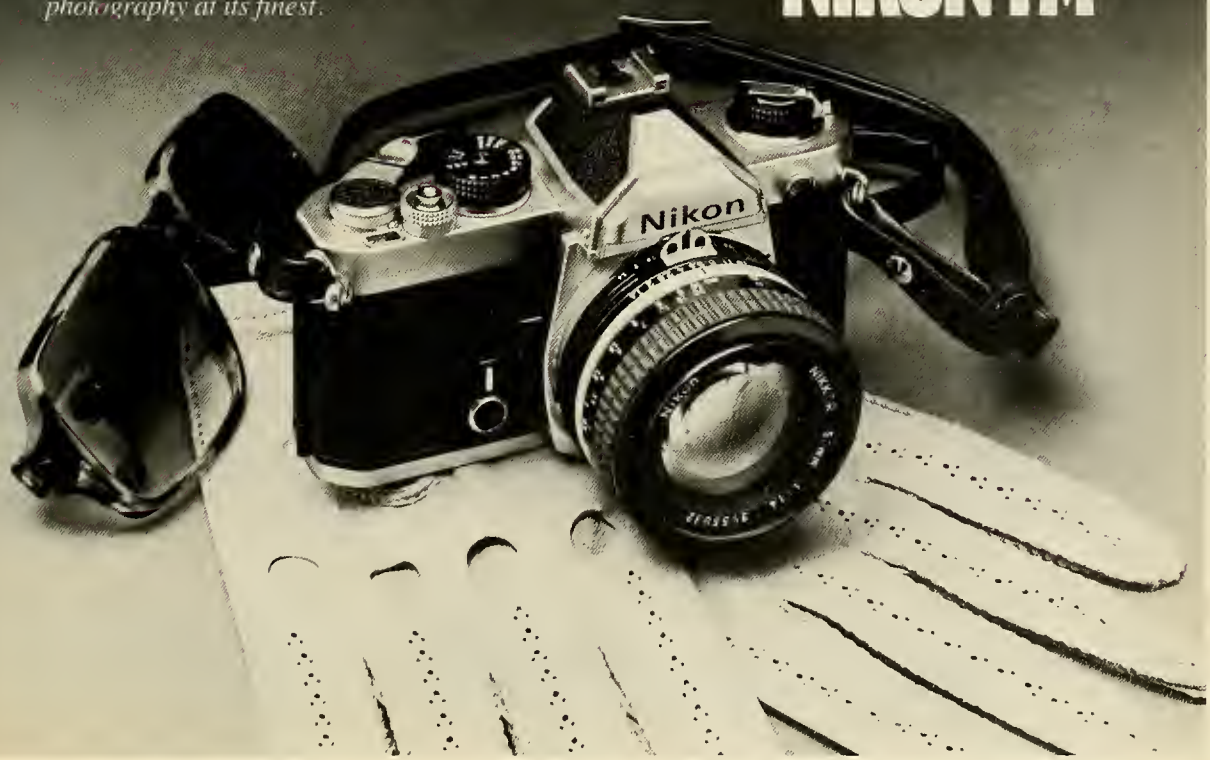
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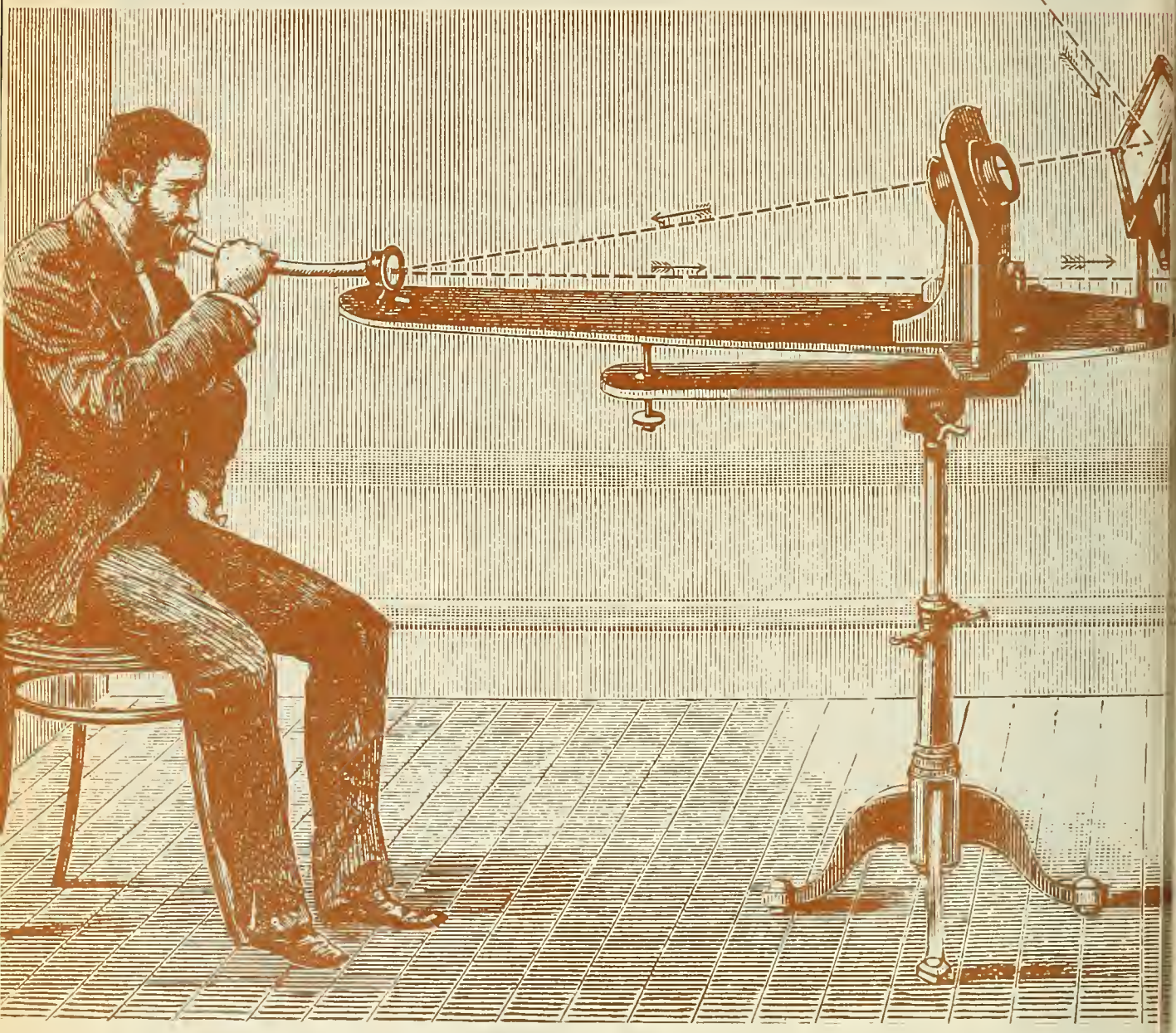
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NIKON FM





In Bell's "Photophone," sunlight was bounced from a reflector through a lens to a mechanism that vibrated in response to speech. This caused the light beam to vary in intensity. At the receiving end, a selenium detector translated these variations into electrical current to recreate speech through a telephone receiver.

77 years before we invented the laser, Professor Bell had a perfect application for it.

In 1880, only four years after he invented the telephone, Alexander Graham Bell received a patent for a remarkable idea—using light, rather than wire, to carry phone calls.

Professor Bell built an experimental "Photophone" that transmitted his voice over a beam of sunlight. It didn't work very well, however.

Sunbeams are scattered by air, rain and fog. In any event, the sun doesn't always shine. The Photophone, unfortunately, was an idea whose time had not yet come.

A new kind of light

By the 1950's, scientists again were looking for a way to use light for communications.

In September, 1957, Charles Townes, a Bell Labs consultant, and Bell Labs scientist Arthur Schawlow conceived a way of producing a new kind of light—extremely intense, highly directional, and capable of carrying immense amounts of information.

Townes and Schawlow received a basic patent on their invention—the laser.

Since then, Bell Labs scientists have invented hundreds of lasers, including many firsts—gas and solid-state lasers capable of continuous operation, high-power carbon dioxide lasers, liquid dye lasers that produce pulses shorter than a trillionth of a second, and tiny semiconductor lasers that work reliably at normal temperatures. Some of these, no larger than grains of salt, may emit light continuously for 100 years.

Getting the light to the end of the tunnel

While we were developing lasers to generate light, we also looked for a way of shielding it and guiding it for long distances and around curves.

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In 1977, the Bell System took lightwave communications out of the laboratory and put it to work under the streets of downtown Chicago. The system, the first to carry phone calls, computer data, and video signals on pulses of light, is working successfully.

Spin-off

Laser light is now used in many other ways—to perform delicate eye surgery, detect air pollution, read product codes at supermarket checkouts, and do a variety of manufacturing tasks. Western Electric, the Bell System's manufacturing and supply unit, was the first company to put the laser to industrial use back in 1965. Hundreds of applications in many industries have followed.

Sometimes, it takes a lot of work and a long time to make a bright idea—like Professor Bell's—a reality. Often, the things we invent, such as the laser, benefit not only Bell System customers, but society in general.

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We work for the phone company. And you.

by Raymond Sokolov

Behind the Tines

The fork placed a barrier between fingers and food

Fingers were made before forks, but so were knives and spoons. The fork as we know it—a small and manageable utensil for individual use, with four (or sometimes three) tines—did not appear anywhere in Europe, except as a curiosity, before the sixteenth century. And the history of its spread from Italy northward parallels fundamental changes in the history of Western manners and civilization that took place after the Reformation.

This is a disrupting notion, as upsetting as the knowledge that Louis XIV ate with his hands until he was an old man. He was probably the last French monarch to plunge his royal fingers into serving platters, but we have it on the authority of an eyewitness, Mme. de Montpensier, that he did so. And from all sorts of other evidence we know that Louis was in the mainstream (in fact the only stream) of European prandial history.

The ancients certainly did not eat with forks. When Horace wrote, "You can drive Nature away with a fork, but she will come right back," he meant something like a pitchfork. The word "fork" comes from the Latin *furca,* a large, double-pronged affair big enough to give its name to an instrument of torture, really a bifurcated yoke set over the victim's neck. His arms were lashed to the two tines. A *furcifer,* or fork-bearer, was a rascal, the sort of rogue who had carried or ought to carry a *furca* around because of his misbehavior. When the seventeenth-century British traveler Thomas Coryate returned home from Italy and ate with a silver fork, his friends, scandalized by such newfangled decadence, dubbed him "furcifer."

In Jacobean England, diners still preserved medieval manners. The most refined people felt no repugnance at touching food. This may seem a small thing, but it stands for a very great difference in consciousness between prefork and postfork cultures. This is the thesis (at least, in part) of a recently translated work in social history, Norbert Elias's *The Civilizing Process: The History of Manners* (Urizen, $15). Originally published (1939) in German in Switzerland, Elias's documentary study of the development of modern civilization shows how the idea of shame evolved and slowly changed every European's threshold of disgust in his relations with others. Elias quotes from a chronologically arranged series of texts on manners, which demonstrate the gradual growth of embarrassment over such matters as sex, excretion, nose-blowing, and flatulence since the Middle Ages. Table manners are Elias's richest case in point. And the fork is at the center of his argument.

"People who ate together in the way customary in the Middle Ages," Elias writes, "taking meat with their fingers from the same dish, wine from the same goblet, soup from the same pot or the same plate . . . such people stood in a different relationship to one another than we do." Normal conduct then would be, by today's standards, "embarrassing or at least unattractive" because it allowed direct contact with "something that had been in contact with the mouth or hands of someone else."

No one can doubt that the modern Western bias against eating with the hands is a cultural artifact. In the Middle East, for instance, the normal way to bring food to the mouth is with the right hand (the left is considered unclean because it is in exclusive use as an adjunct to excretion). Innumerable other cultures do not employ special eating utensils. But, as Elias proves, the peculiar, fork-wielding refinement of the West is a historical, as well as a cultural, phenomenon. In a sixteenth-century book of etiquette, Erasmus observed: "Some put their hands into the dishes when they are scarcely seated." His idea of good manners was to wait one's turn instead of lunging at the serving dish with the hands. Erasmus also counseled against hunting around in the serving dish for the best piece. The refined person, he said, used only three fingers, and also washed his hands before the meal (with water; there was no soap). After eating, it is impolite, Erasmus continued, to lick one's greasy hands or wipe them on one's coat. Such were the strictures of correct dining about 1530.

Little had changed by 1560, when

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a treatise on manners stated that a child "must not lift meat to his mouth now with one hand and now with the other, like little children who are learning to eat; he should always do so with his right hand, taking the bread or meat decently with three fingers only."

By the end of the seventeenth century, a modern reticence creeps into this robust etiquette. Antoine de Courtin, in his *Nouveau traité de civilité*, says that "if everyone is eating from the same dish, you should take care not to put your hand into it before those of higher rank have done so." Courtin also suggests wiping the spoon before serving oneself, "there being people so delicate that they would not wish to eat soup into which you had dipped it after putting it into your mouth."

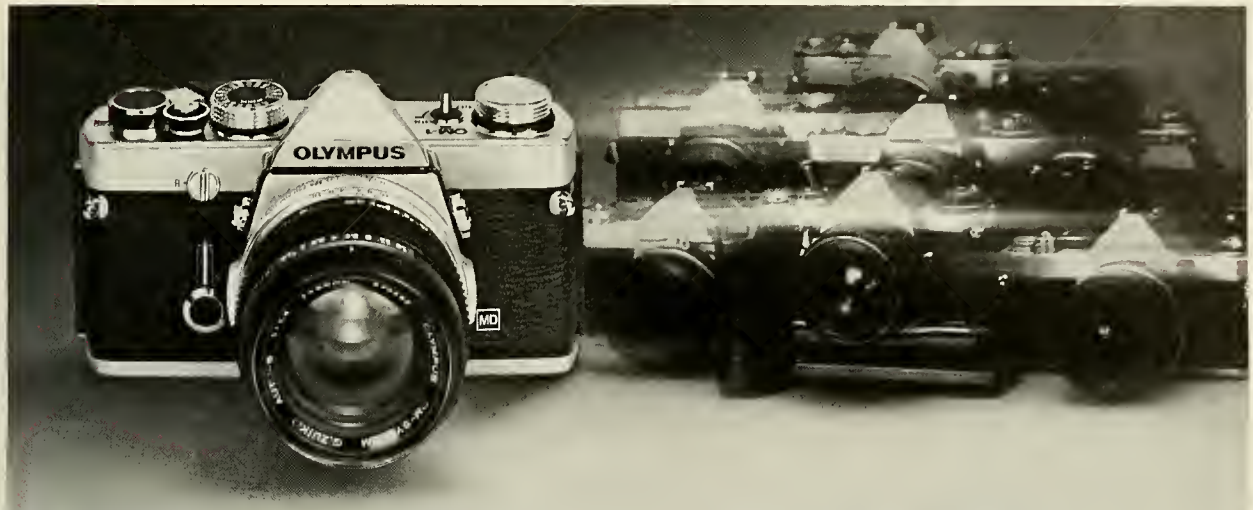
Clearly, the world was now ready for the fork and for the protection against contamination from human hands that it could provide. In a song written between 1640 and 1680, the Marquis de Coulanges wrote:

> In times past, people ate from the common dish and dipped their bread and fingers in the sauce.
> Today everyone eats with spoon and fork from his own plate, and a valet washes the cutlery from time to time at the buffet.

Even if the song celebrated an extreme instance of the new civility, by 1729, an etiquette manual published in Rouen declares flatly that "at table you should use a napkin, a plate, a knife, a spoon, and a fork. It would be entirely contrary to propriety to be without any of these things while eating."

Fork etiquette developed rapidly in the eighteenth century. Today, we still eat in much the same way as our revolutionary ancestors. The only subsequent changes have been matters of detail: the uses of specially shaped salad forks, oyster forks, fish forks, and even those throwbacks to the premodern, two-tined fork, fondue forks (see recipe below).

Now it would be unthinkable to dispense with forks at any normal meal; one can imagine making do without a knife or a spoon, but a fork, never. I can remember, when I was eleven, how funny it seemed that another child my age ate his dinner only with a spoon. How un-



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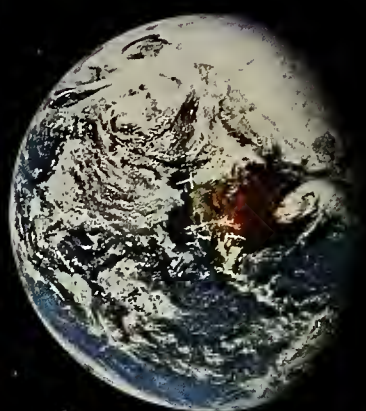
civilized. But how historically narrow of me. Perhaps, too, at that age, I was still close enough to having learned to hold and use a fork properly that I took a parvenu's pride in my own ability to hold one, not like a "stick," but between the fingers. I have, however, always rebelled at the fussy American custom of switching the fork from the left to the right hand after cutting. There is no logic to this choreography, and as a left-hander I am happy to claim the company of all Europe in my disdain for it. To her credit, Amy Vanderbilt also takes a permissive view of the matter.

She is even willing to permit us to eat certain kinds of foods with our fingers, although reluctantly. Artichoke leaves, in the Vanderbilt system, are to be pulled "dexterously" through the teeth. Bacon is finger food only if very crisp. Shoestring potatoes, "if really dry and impossible to eat with fork, may be eaten in the fingers." And so on. Vanderbilt's fussiness stems from the same historical impulse Elias traces to the sixteenth century. She wants, as much as possible, to put a flatware barrier between food and hands. The best reason for this delicacy has, to a great extent, disappeared with the universal adoption of serving implements.

Still, there is a good modern reason for keeping our hands out of our food as much as possible. Cleanliness, for its own sake, is the only current justification for forks. Even this notion, however, goes back to the Renaissance, when, Elias notes, the very words for "proper" and "improper" in French (*propre* and *impropre*) came to mean "clean" and "unclean."

Nevertheless, the fork rule is relaxed in two eating situations that symbolize the conditions of life outdoors. We eat corn on the cob with our hands not only because it is simpler to do so, but also because it is preeminently a food of the fields, ideally consumed only minutes after picking and before natural sugars evanesce. Small game birds also should be picked apart with the fingers both for practicality and because partridges and grouse, however elegant, remind us of the premodern and even preagricultural era when hunters gathered around a fire and ripped apart their quarry hot from the spit. Fried chicken is an intermediate case. This domes-

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Split Time...is the mode you'll use to get the time for the 1/4 and 1/2, 3/4 in a race, and the individual times of each contestant across the finish line. Think of it! Stopping for split times does not stop the timing of the event itself from continuing. It's actually stopped and running at the same time, so you can use it to figure out the time of pit stop, for example, and still get the over-all running time of the race.

Lap Time...is even more ingenious. It stops to measure an event and simultaneously starts again from zero. In a relay race, for example, you stop the chronograph the instant the runner passes the baton; this gives you his time while the lap timer automatically starts counting the next runner's time. Similarly, in a football game, you can get the exact time it takes a punter to kick the ball, the time the ball's in the air, and then the time of the run back of the punt. Any event, from a rocket launch to a production process, can be split into its component parts this way. Separating the time of elements that cannot be separated in any other way!

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ticated megapartridge is more accessible if you pick it up and gnaw —and if it is *properly* fried, it is fairly clean to eat.

Finally, I want to mention a related problem in dining etiquette, overlooked by Elias and perhaps too leniently dealt with by Vanderbilt: cherries. Vanderbilt, like any sensible person, allows us to pop cherries into our mouths whole, with the fingers. The trouble comes later. Can it possibly be polite to spit the pits into the cupped hand and put them back on the plate? Vanderbilt says so, but who has not felt embarrassed at ejecting something from the mouth at the dinner table? What could be more medieval and unattractive? The solution to this predicament was reportedly arrived at not long ago by a candidate for a fellowship at Oxford's prestigious All Souls College who, at a formal dinner that was the final hurdle before his appointment, looked about him furtively, his mouth full of cherry stones, knowing that the assembled dons were coldly watching him squirm on the horns of the dilemma they had maliciously contrived, and, with Erasmian aplomb, swallowed the pits. He was elected to All Souls and lived to enjoy his sinecure.

Compared to that feat, the question of which fork to use for which dish is child's play. Simply work from the outside in. Silverware set above the plate is for dessert. When in doubt, watch your hostess or some other figure of propriety. But, above all, never ask. An excessive concern with forks is a mark of the provincial, as well as a sign of puerile interest in the decadent phase of an antique shift in manners. The best rule is: Get fed, stay as clean as you can, and attract no attention.

Nika Hazelton's
Basic Cheese Fondue
(Slightly adapted from Mrs. Hazelton's *The Swiss Cookbook*)

1 pound imported Swiss cheese, or half Emmentaler and half Gruyère, shredded or diced, or the equivalent in slices, finely cut
3 tablespoons flour, or 1½ tablespoons cornstarch
1 garlic clove
2 cups dry white wine
1 tablespoon lemon juice
3 tablespoons kirsch (or brandy, gin, or whisky)
Nutmeg, pepper, or paprika to taste
2 loaves Italian or French bread, cut in cubes so that there is crust on one side of each cube

1. Dredge the cheese lightly with the flour or cornstarch.
2. Rub the fondue pot with garlic.
3. Pour in the wine and set over moderate heat.
4. When air bubbles rise to the surface, add lemon juice. Then add the cheese by handfuls, stirring constantly, in figure eights, with a wooden fork or spoon until the cheese is melting.
5. Add the kirsch and spices, stirring until blended.
6. Set over a low flame at the table.
7. Spear the bread cubes with long-handled, two-tined forks, pushing the tines through the soft side and into the crust, to anchor them. Dunk and swirl in the fondue.

Yield: Four servings

Note: The fondue must be kept barely bubbling at the table. Regulate the flame accordingly. As the fondue is consumed, you may have to turn the flame off and on to achieve a low enough heat. If the fondue should become lumpy or separate, put it back on the stove, stir it thoroughly with a wire whisk and add ½ teaspoon cornstarch diluted in a little wine. Immature cheese tends to form threads. If the fondue becomes too thick because of the continuous cooking and evaporation of the liquid, it can be thinned by adding some warmed wine. If the mass does not amalgamate, add ½ teaspoon diluted cornstarch.

In Switzerland, in a restaurant, whoever drops the first bread cube into the pot pays for the meal. In private homes, this is perhaps the appropriate moment to contemplate the mechanical superiority of four-tined over two-tined forks. Hazelton asserts that, in a pinch, metal skewers or even knitting needles can be substituted for fondue forks. *Crede expertae,* but if you try these desperate measures, watch out for falling bread.

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.



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Twelve collector's plates by the world-famous artist Jeanne Holgate.
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Plate shown smaller than actual 7¾" size.

This is the first collection of its kind ever issued by the Sierra Club, and it is available in exceptionally limited edition—by subscription only.

The subscription deadline is August 31, 1978.

The flowers of the American wilderness are among the most beautiful of our natural treasures. Delicate, graceful and vibrant, they have the power to stir the heart as well as the senses. Yet so elusive is their beauty that it is a rare artist indeed who can capture it with accuracy and realism.

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By order of the Sierra Club, *Flowers of the American Wilderness* will be produced and issued *only* by direct subscription. The total number of plates to be issued will be sharply and permanently restricted in the manner long ago established to assure the rarity of the finest porcelain plates. Thus, there is an absolute limit of just one subscription per person, and the total edition of the collection will be forever limited to the exact number of subscriptions entered by the official deadline.

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But please keep in mind that the Sierra Club's *Flowers of the American Wilderness* plate collection is available for only a limited time. To subscribe, complete the application below and mail it by August 31, 1978.

There is no need to send any payment now. But please be sure your Subscription Application is postmarked no later than August 31st.

JEANNE HOLGATE's work is a permanent part of the great floral art collections of the world—including those of the Carnegie-Mellon University's Hunt Botanical Library, the British Museum, and the personal collection of Her Majesty Queen Elizabeth, the Queen Mother of Great Britain. She is the only artist ever awarded successive gold medals by the Royal Horticultural Society.



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Notes From a Rice Paddy

If the climate is right, even an amateur farmer can grow enough of this life-sustaining commodity to feed a family

Rice is the main food for half the world's population. There are thousands of varieties of rice. All are crops of warm climates and only a few new types produce well where the mean temperature is 70°F (or higher) for less than four months of the year.

In the United States, rice culture began in South Carolina in 1694, but almost all of our rice is now grown in limited regions of Arkansas, California, Louisiana, Mississippi, and Texas. The nutritive value of milled rice is about that of potatoes, but in the rough, or unhulled, form at everyday temperatures, rice can keep for several years—much longer than raw potatoes.

Yields around the world vary widely, from only 1,000 pounds per acre on unfertilized plots dependent on fluctuating rainfall to more than 6,000 pounds per acre where plant variety is matched to optimum conditions of soil, water, and temperature. United States production in 1976 was nearly 13 billion pounds from 2.8 million acres, for an average yield of 4,600 pounds per acre. More than half of our production is exported—major customers include South Korea, South Africa, the Arab countries of the Mideast, and some western European nations.

In the United States, commercial production is energy intensive and usually employs chemical aids. Rice seed is either sown by airplane in flooded fields or planted with grain drills in fields drained for planting and subsequently flooded. Weed-control herbicides such as 2,4-D are commonly applied by airplane. Fields are drained again before harvest and allowed to dry sufficiently for combines to be used. Rice is hulled in centrally located mills—the largest process as much as a billion pounds in a year. Milling nowadays is often preceded by special processing, which first places rough rice under vacuum to remove air from the hull and kernel; then steams it under high pressure. This practice, akin to parboiling, drives some vitamins and minerals from the rice hull into the kernel, thereby producing a more nutritious, longer-lasting final product. Milled rice is often further enriched with vitamins and minerals before being packaged for distribution to markets.

Civilizations tend to be only as strong and enduring as their agricultural bases—it is accordingly an understatement to say that we should be concerned with what is going on in U.S. agriculture. Commercial rice culture in the United States illustrates many features of our total agricultural system. It involves extensive use of fossil fuels to power machinery, to fertilize, and to control insect and plant pests. Most of us are better fed than former populations. But our technological agriculture has also introduced harmful synthetics into the environment and replaced crop rotation with chemicals, resulting in the loss of humus and increased erosion of sloping lands.

Our systems for the preservation and widespread distribution of agricultural products have given us year-round access to many heretofore seasonal foods, but some of us miss the flavor of fresh, naturally ripened produce, which is seldom available nowadays.

Please turn to page 38

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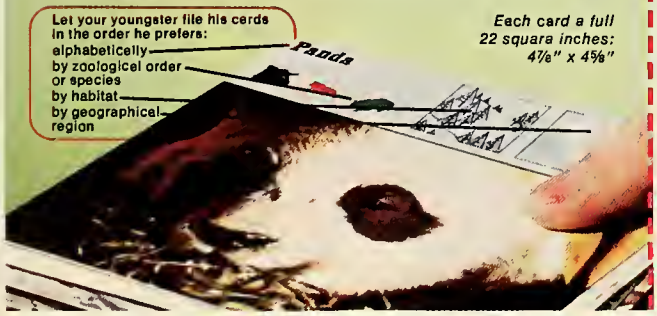
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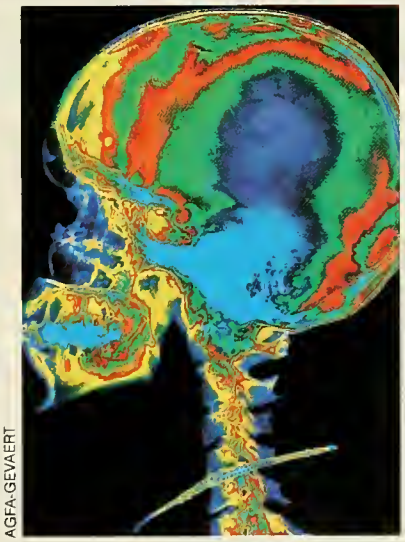
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Bushnell Give us a look

Our energy-intensive farming has been associated with social changes —there are fewer farmhands in the nation now and more unemployed workers in the cities. Since our agricultural methods rest significantly on the depletion of nonrenewable resources, they resemble some other features of our socio-economic structure in that they probably cannot be sustained over the long term.

My maternal grandfather was a farmer and rancher in south Texas, so I was exposed to commercial agriculture as a youngster during the early 1940s. After ten years of adult life in Norman, Oklahoma (population about 60,000), and with our two sons out of high school, my wife, Lottie, and I agreed that we should try living on a farm.

Our 220-acre farm is mostly pasture. The original part of our house was built by a family of Choctaw Indian descent, which claimed 80 acres when the Indian lands in Oklahoma were allocated to individuals at the start of this century. I use a lot of old, but still functional, farm equipment that is not in great demand by full-time farmers. Most of it was purchased for about 15 percent of the cost of new equipment. Our farm income, which is derived principally from honey sold to health food stores, amounts to less than $1,000 per year. My agricultural experiments consequently depend for their support on my income as a meteorologist.

We have some cows and calves, chickens and ducks, a productive apiary, a fine garden, a developing orchard, and a lovely creek. Some of the numerous wild animals share our produce, but they, in turn, are kept in check or at bay by our dogs and cats and by various ad hoc strategies. There is plenty of work, but we get some important help from a friendly neighbor. We take much pleasure in our animals and get much satisfaction from farm life. And we are learning.

For example, after three seasons of experimentation, I have developed a system of rice cultivation that produces a good yield with very little labor and no commercial fertilizers, pesticides, or herbicides. My paddy is a 734-square-foot oblong plot in which water normally stands after heavy rains, making it unsuitable for common garden crops. The topsoil is a dark loam, underlain by

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Don Whitlock's original lithograph *Brisk Breeze.* Signed limited edition of 200.

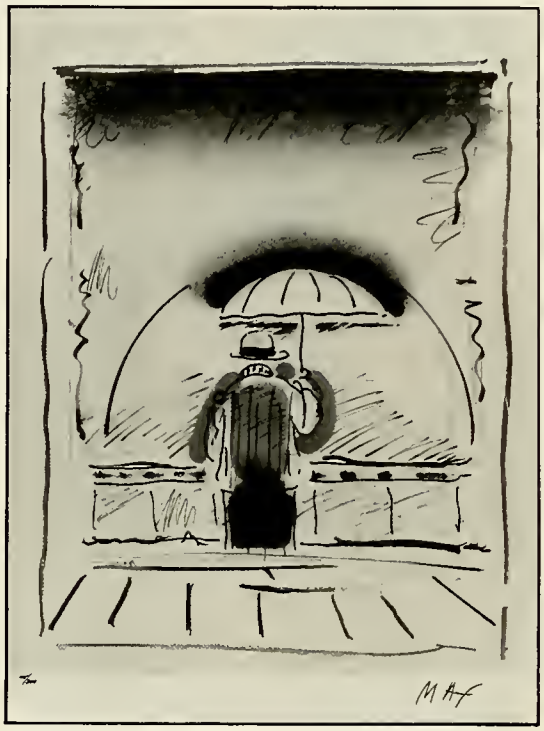
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Louis Toffoli's original lithograph *Femmes a la Potiche.* Signed limited edition of 125.

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Peter Max's original lithograph *Man With Umbrella.* Signed limited edition of 300.

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a slightly pervious clay. An irrigation system provides water from Finn Creek, made perennial by an upstream water-retention and flood-control project built in 1965 by the Soil Conservation Service.

In late winter or early spring I spread about 200 pounds of old cow manure on the paddy and plow it into the soil with the residue from the previous rice crop. For uniform distribution of water to the new crop, I level the paddy with a rake, boards, and a level indicator. Planting sprouts instead of ungerminated seed gives the rice a start over ungerminated weed seeds. So I place wet rough rice from the previous crop in a covered can on top of a hot-water heater. The seed sprouts very rapidly and is ready to plant in a few days. About two pounds of seed corresponds to the usual planting rate of a little more than one hundred pounds per acre. I use a Rototiller just before planting; this eliminates started weeds and provides an appropriate seedbed. The slightly sprouted rice is broadcast carefully by hand, raked gently to hide it from birds, and then watered to provide a shallow cover. Planting time in central Oklahoma is from May 1 to May 10.

I have heard that the planting of germinated seed is practiced in the Philippines, but the traditional Oriental method of rice growing involves cultivating the seedlings in separate beds and then transplanting them. With the transplanting method, two or sometimes three crops a year can be grown in the same rice paddy if the climate is suitably warm. Transplanting established plants gives the rice a strong advantage over weeds, which then grow only poorly in the shade of the larger rice plants. The airplane method of seeding is very fast, of course, but probably not adapted to the use of tender sprouted seed. In most commercial practice, the rapid natural ascendancy of sprouted or transplanted rice over weeds, coupled with some manual labor for residual weed control, is traded for weed control by chemical methods. The planting of germinated seed is probably a good method for small-scale farming in the United States, since in most of the country the warm season is not long enough for two rice crops and weeds can be particularly troublesome when the germination of unsprouted rice



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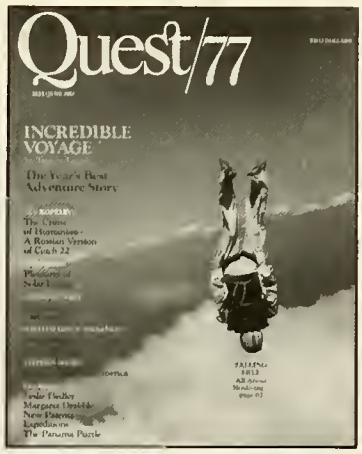
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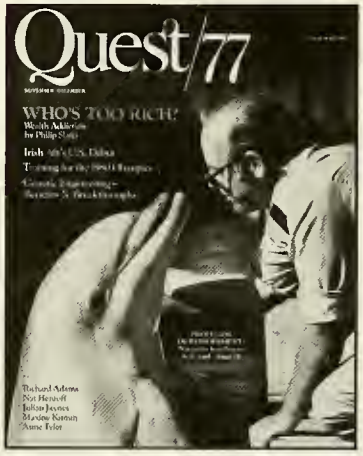
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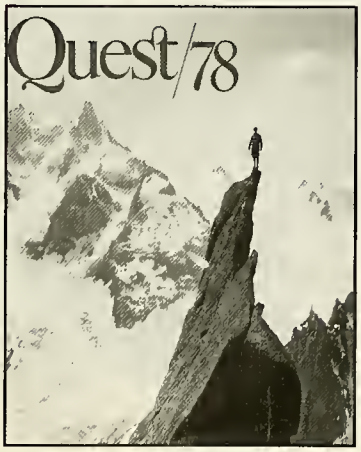
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seed is delayed by cool weather.

Rice is a beautiful plant and grows rapidly during Oklahoma's typically hot July and August. In 1977, my paddy required only one major weeding, which I did in about two hours with feet kept bare so the rice plants could be felt and not trampled. A major weed is barnyard grass, which resembles rice until the seed stalks appear, but which is a slightly darker green, has a diminutive or absent ligule, instead of the conspicuous pubescent ligule of rice, and stems that are reddish at the base, while those of rice are nearly white. A broad-leaved aquatic weed with shallow roots is also common in my paddy, but it is easily pulled up and eaten by our ducks. During midsummer, the water surface shows tints of blue, indicative of nitrogen-fixing blue-green algae. The paddy is not a significant source of mosquitoes, which are apparently controlled by the numerous frogs attracted during the summer growing season.

I harvest the rice when the kernels show the first signs of falling from their panicles, about September 20 in Oklahoma. My harvest date has been insensitive to the planting date, depending instead on the variety of rice used. Birds are not a serious pest unless the rice stalks are blown down, or lodged, by a severe storm; the stalk is not stiff enough to give even small birds a good perch. I harvest the rice by hand in about an hour by successively gathering together all the stalks I can embrace and cutting them off with a knife. After the harvested stalks have dried for a few weeks in a large wooden tray in the barn, I remove more than 95 percent of the grain in about fifteen minutes by striking the mass of stalks with the flat of an ordinary pitchfork. The grain falls to the bottom of the tray, and the stalks with unthreshed grain are worked over by eager chickens.

The unpalatable rice hulls cling closely and tenaciously to the kernels. Hulling consequently represents a major obstacle for the small rice grower. The Oriental pounding and rubbing methods involving a hollowed-out log seem ill-adapted to our ways, although not having guidance in such arts, I have probably not given them a fair trial. Another technique, small, electrically powered rice hullers used for test-

ing grain sampled from commercial lots, seems expensive for the small farmer (huller prices started at about $600 in 1976). In my first hulling method I used a tray lined with carborundum paper and rubbed the rice with a similarly coated wooden block, but this procedure is painfully slow and produces some undesirable grit.

In 1976 I purchased, for $143 delivered, a Java hand-operated huller manufactured in England. This small, sturdy machine, which should last for decades, yields five to ten pounds of milled rice per hour in an easygoing operation by one person, including simple winnowing of the outturn mixture of kernels and separated hulls. The final product—brown rice, since only the outer husk is removed from most kernels—cooks in twenty minutes. The amount to be eaten in a month is all that should be milled at one time because brown rice is vulnerable to attack by insects and its oil can become rancid (of course, these risks are minor if the rice is refrigerated).

My paddy, although poorly leveled in 1977 owing to an error, provided 55 pounds of rough rice after threshing, which corresponds to a yield of about 3,200 pounds per acre. Approximately two-thirds of my total came from the half paddy that was better watered, so I anticipate a yield of 70 to 75 pounds with better leveling. But even 55 pounds is more than adequate for a family of four, since the annual per capita consumption in the United States is only 7½ pounds of milled rice, derived from about 11 pounds of rough rice.

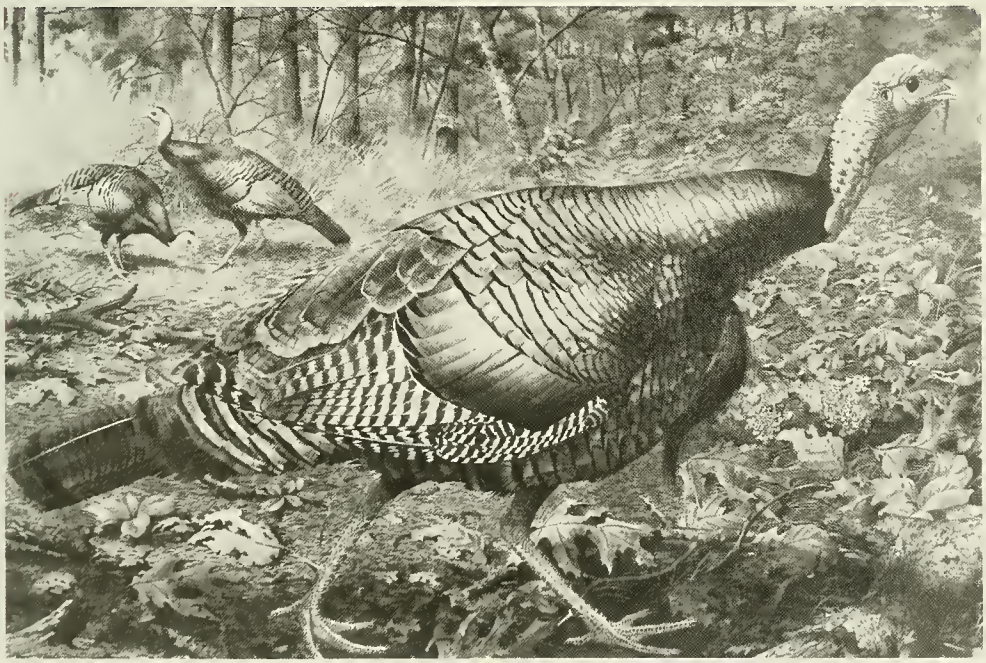
Some additional notes. My rice is Nova 66. I judge that given suitable land and sufficient water of good quality, the manual method of planting rice sprouts is practical for a small farm family cultivating up to an acre of paddy. This carries implications of a significant financial return on labor, since the current retail price of rice in health food stores is more than 50¢ per pound.

If an acre is planted, a small combine would be an appropriate aid, and the Java huller would need a simple conversion to belt drive to mill about thirty pounds of rice per hour. Deep water is not necessary on rice plants, although depths of six inches provide strong control of weeds. But a minimum water depth of an inch or two is required to keep the paddy continuously wet until the rice kernels are well filled out. I watered for forty minutes every second or third day during the hot, dry summer of 1977 and estimate that less than $1.50 was spent on electricity for my one-horsepower pump throughout the season.

Overfertilizing will result in lush vegetative growth and lodging of the stalks. I now apply cow manure once before planting and leave the rest to the algae. The U.S. Department of Agriculture and other agencies provide instructions for achieving maximum yields by fertilizing during midseason. The benefits of commercial processing can be approached by parboiling rough rice and redrying before hulling. This practice is common in many of the less-developed countries where rice is grown in small plots for local use.

Edwin Kessler, a meteorologist, is the director of NOAA's National Severe Storms Laboratory in Norman, Oklahoma.

WILD BIRD PORTRAITS BY BASIL EDE

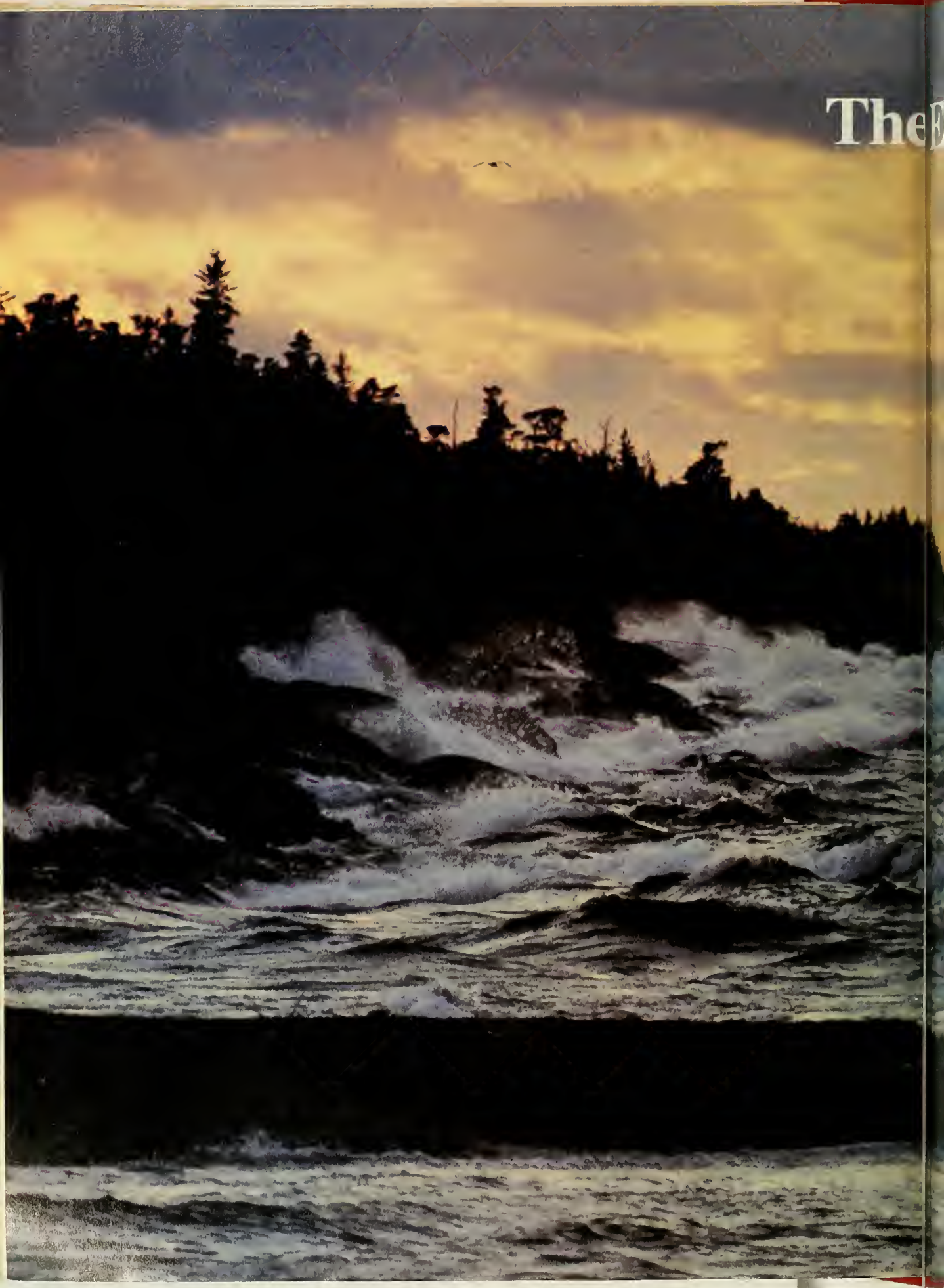


Ede's beautifully detailed bird portraits have won wide acclaim in the world of fine arts as well as among outdoorsmen and bird enthusiasts. Ede visited Alabama to study the wild turkey in the forests. For 15 minutes he watched one from only 12 feet away and termed the experience "awe inspiring". THE GREAT AMERICAN TURKEY IN SIPSEY RIVER VALLEY, one of a series of the Birds of America by Basil Ede, is published in an absolutely limited edition of 750. Image size: 20½"h x 30½"w with ample margins. $250 signed and numbered. $350 remarqued. Alabama residents add 6% sales tax.

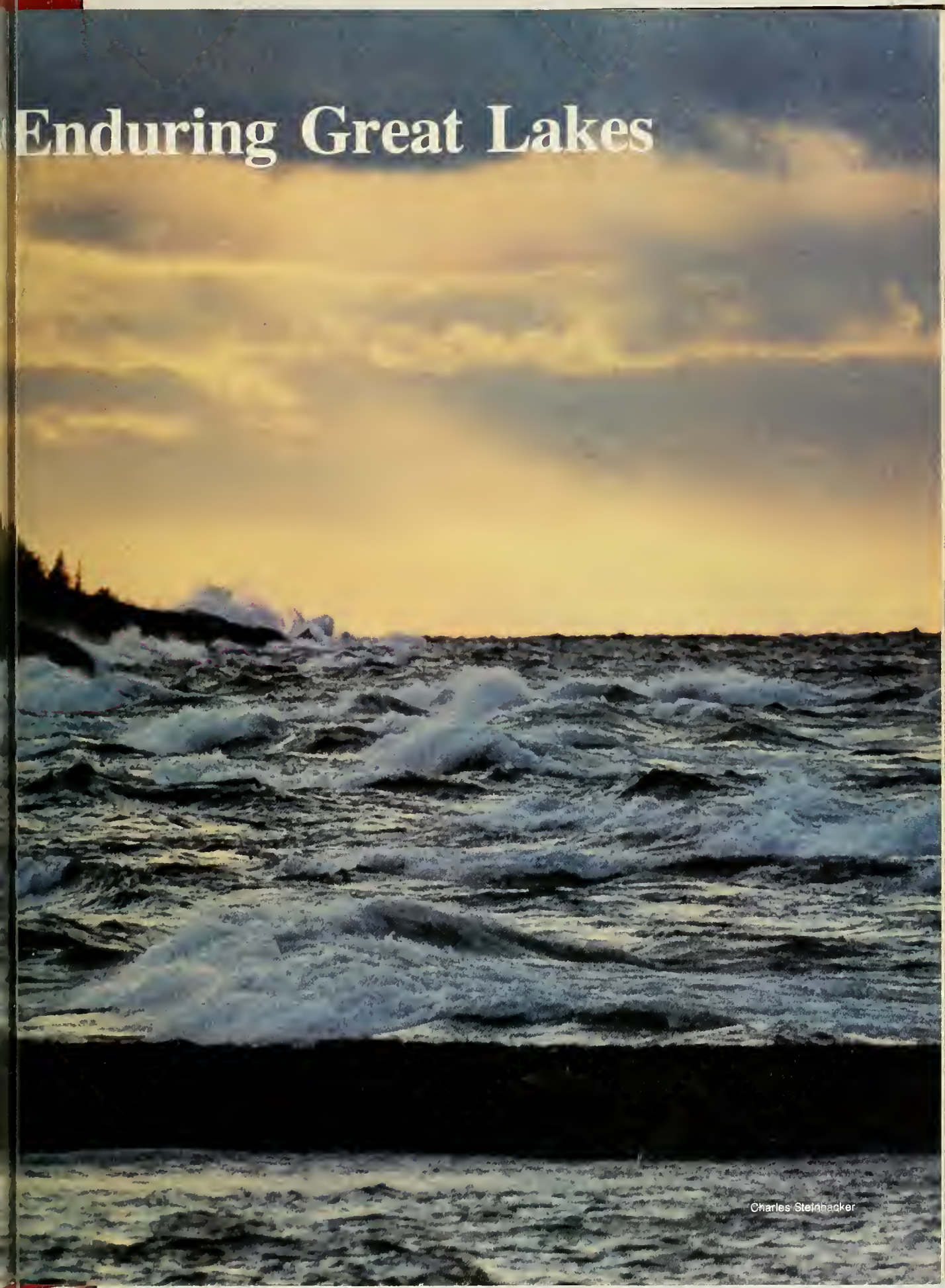
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The

Enduring Great Lakes



Some shorelines of the Great Lakes have retained their wildness. Pages 46 and 50: Waves break on the coast of Michigan's Keweenaw Peninsula in Lake Superior. Below: Thomas Davies's 1766 painting of an Indian family at Great Seneca Falls, Lake Ontario.



The National Gallery of Canada, Ottawa

Ironies of the Great Lakes



The Great Lakes of North America are ironical natural phenomena, often described in metaphor or in wonder. Herman Melville chose metaphor when, in *Moby Dick,* his Ishmael portrays the lakes to an incredulous Spaniard: "Those grand fresh-water seas of ours," Ishmael brags with Jacksonian pride, "possess an ocean-like expansiveness, with many of the ocean's noblest traits. . . ." The wandering sailor is unable to describe these strangely misplaced seas without identifying their "wild barbarians," "ancient and unending forests," and "Borean and dismasting blasts as direful as any that lash the salted wave"—qualities more closely associated with Cape Horn than with inland lakes.

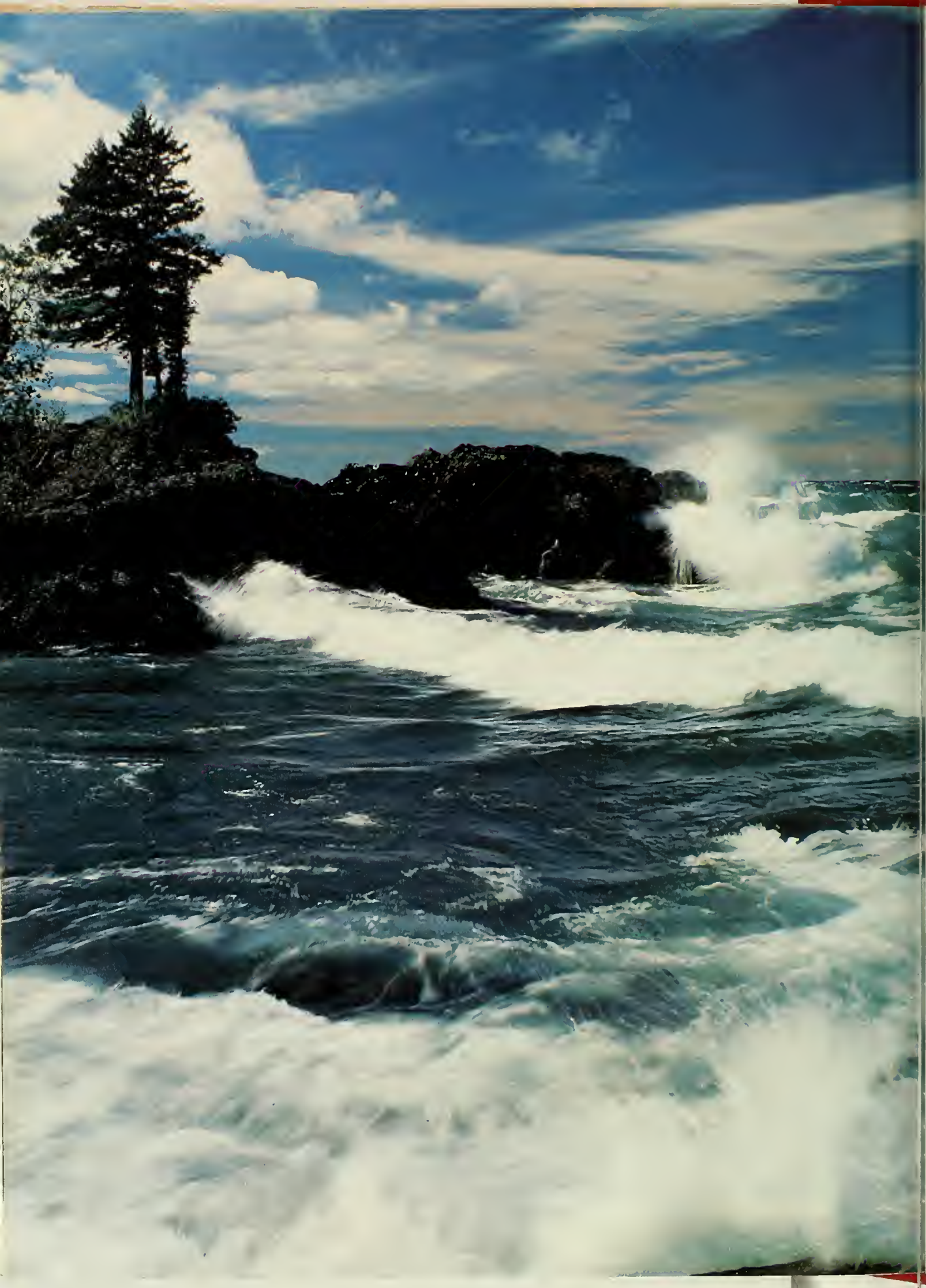
Ecologist Eugene F. Stoermer, an author in this issue who has studied the Great Lakes for many years, turns to wonder. He first saw Lake Michigan when he was six. "It looked very impressive and mysterious then to a farm boy from Iowa," he says, "and, in some respects, is even more so today."

The irony, the mystery, and the metaphor are inspired by the truth that, despite their size and power, the Great Lakes are filled with fresh water. Once so lacking in chemicals that it was as pure as rain, lake water remains remarkably clean and continues to define aquatic life in special ways: layering and unlayering itself in a seasonal cycle; encouraging only certain plant and animal life; responding sometimes like and sometimes unlike salt water to such natural forces as the earth's rotation and temperature changes.

A second irony about the Great Lakes is that soon after the European discovered ways to exploit them, he unknowingly began to accelerate the water's slow, natural aging. The lakes were all things to all people—wells, cooling agents, platforms for transportation and recreation, sources of food, dumps for waste. Only recently have scientists been able and encouraged to discover the complex ways in which rapid aging has degraded the once-pure, apparently infinite resource. This special issue is a research report on the unfolding natural history of the Great Lakes.

For more than a generation, the alarm "the lakes are dying" has rung through popular discussions of the status of the Great Lakes. The authors in this issue, however, share a deep respect for the continuing good health of the lakes, as well as a cautious optimism about the future. Clifford H. Mortimer (like Ishmael, a user of metaphors) writes: "The play has changed and some actors have left, but there has been an encouraging resilience in the show's response to various threats to its continuance."

John Rousmaniere



Props and Actors on a Massive Stage

A number of chemical, physical, and biological processes keep the Great Lakes' annual "play" in production

by Clifford H. Mortimer

In the Great Lakes, the life cycles of individual organisms provide a number of fascinating, although brief, scenarios. But together, all the agents of change among the plants, birds, and fish become a full-length play on the massive stage of the Great Lakes basin.

Several important props must be described before we get to the play's narrative. One is the relative shallowness of the lakes, scraped out some 10,000 to 15,000 years ago by receding ice sheets. Another is the size of these inland seas, so enormous that the earth's rotation plays, through the Coriolis force, a major role in the dynamics of the Great Lakes, as it does in the oceans. And because the lakes all outflow either into each other or into the Saint Lawrence River and differ in surface size and in volume, they all have different water residence times.

The geology of the lakes affects both their water quality and the principal land uses in their catchments. Land uses are primarily determined by bedrock and the related soil, both of which show strong north–south contrasts in the lake basin. In the north, the Lake Superior catchment and much of the Lake Huron catchment lie on igneous rocks of the Canadian Precambrian Shield. The rocks of these "upper" lakes weather slowly, adding few nutrients to nurture either land or aquatic plant life. In the south, most of the drainage into Lake Michigan and the "lower" lakes—Erie and Ontario—comes from glacial drift deposits that cover sedimentary rocks. These yield a rich nutrient soup. With relative ease, early settlers cultivated the soils around Lakes Michigan, Erie, and Ontario, in contrast to the difficulty of farming the thin, infertile soils of the north. Human settlement and land use responded to the north–south differences. More people settled in the south, further increasing the amount of nutrients—to poisonous levels—in the lower lakes.

The water in each lake reflects the differences in these geologic and land-use characteristics, as comparisons between Lake Ontario and Lake Superior point up. The salt content of Lake Ontario's offshore waters is 170 parts per million; that of Lake Superior's is 35 parts per million. Sufficient light is available for photosynthesis to a depth of 55 feet in Lake Ontario's offshore waters; to a depth of 125 feet in Lake Superior's offshore waters. Measurements of salt content and transparency for Lakes Huron, Michigan, and Erie fall between those of Superior and Ontario. Lake Huron's Saginaw Bay—one of the most polluted areas in the lakes—has a salt content of 240 parts per million and a transparency of only 20 feet. The concentrations of two important nutrient salts, phosphate and nitrate, show even more striking differences.

In order to grow, the plant life of the lakes requires energy from light, as well as nutrients. The turbidity and color of the water, which vary greatly with the season and location, determine penetration of sunlight into the lakes. In general, the lakes with the least nutrients have the greatest transparency.

With those props—the geochemical characteristics of the Great Lakes basin—the curtain can go up on the seasonal cycle in winter. Except in shallow Lake Erie, which may freeze over, wind and wave action combine to break up temporarily formed ice sheets on the offshore waters of the lakes. Well stirred by the wind, the waters cool down to several degrees below the 40°F temperature of maximum density. Friction along the shoreline imposes resistance to stirring, but due to the large size of the lakes, the bottoms offer little resistance. As the water slowly warms up in the early spring, however, layering of waters by temperature—called thermal stratification—develops and terminates the mixing.

Thermal stratification begins when the water near shore warms up first and, as it reaches 40°, becomes denser than the colder, well-mixed offshore waters, whose temperature is typically 36°. As the nearshore water heats up, it divides into layers, with the densest 40° water at the bottom and with stratifications of warmer, hence less dense, water resting on top of each other. The nearshore and the offshore water masses become separated from each other by a narrow, nearly vertical curtain of water, called the "thermal bar." As the offshore waters gradually heat up in spring, the thermal bar migrates out into the lake.

We used to think that the thermal bar remained stable vertically as it advanced offshore because it drew warmer and colder water into it from both sides. But, exposed as the Great Lakes are to wind action, this seems unlikely. We now know that the stabilizing factor is the Coriolis force arising from the earth's rotation. In the Northern Hemisphere, this force always directs a current ninety degrees to the right of its initial flow. Here, this force tends to counter an offshore-aimed current (caused by the temperature difference between nearshore and offshore waters), creating a state of equilibrium at the surface and in deep water.

Upon this moving stage, and controlled by its mechanics, the first act of the year's biological production cycle takes place. Illuminated by spring sunshine, microscopic algae (phytoplankton) photosynthesize to become the initial crop of "grass," which then nourishes a community of zooplankton. Both the food and the eater drift where currents and gravity take them. The *rate* of photosynthetic production is largely

Stan Osolinski

Opposite, a satellite photograph taken from east to west emphasizes the size and sprawl of the Great Lakes. Below, development and movement of the thermal bar and thermal stratification in Lake Ontario, April–June 1965.

controlled by the *ratio* of two depths: the depth from the surface to which photosynthetically usable light energy penetrates (the photic layer), and the depth from the surface to which active, turbulent stirring is maintained by winds and currents (the mixed layer). If the photic layer is shallow and the mixed layer deep, photosynthesizing algal cells (principally silicate-requiring diatoms in the spring) will spend, on average, much less time in the light. They therefore grow at a slower rate than they would if the photic layer were deeper or the mixed layer shallower.

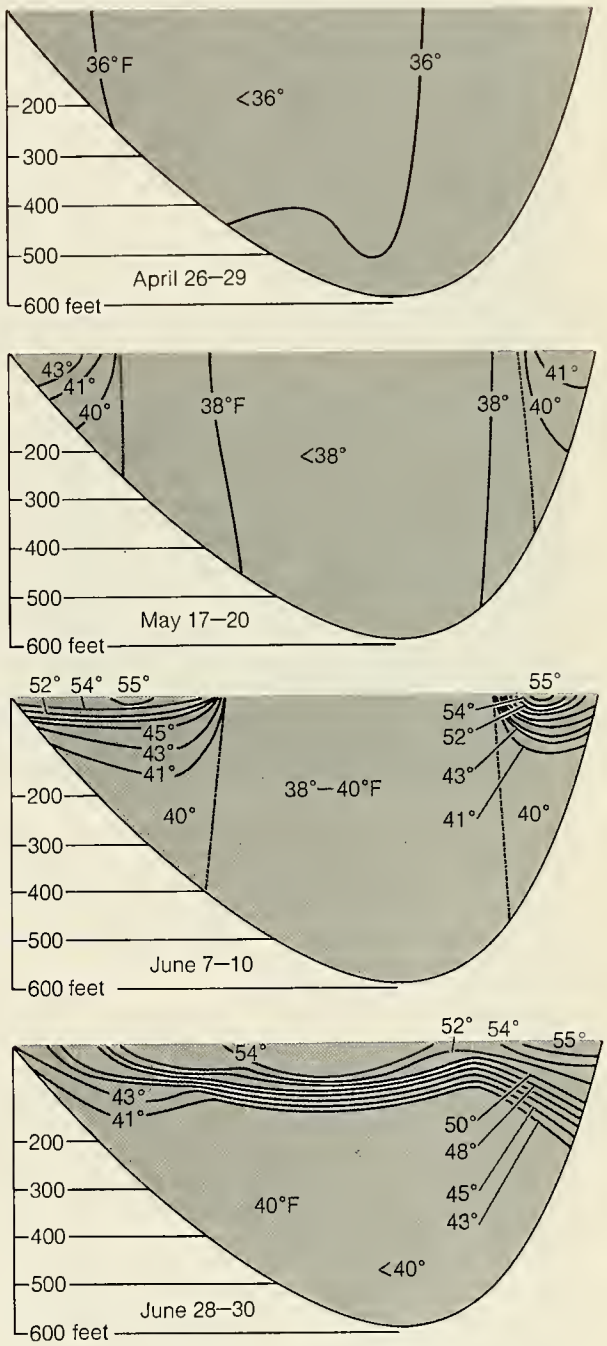
In the lakes in spring, a surface water sample taken on the inshore side of the thermal bar, where the mixed layer is rendered shallow by stratification, is a green suspension of diatoms, while an offshore sample from the deep mixed layer remains clear. The causes of this striking difference have more to do with the mechanics of turbulence than with the availability of light or of nutrients, both of which are relatively plentiful at that time of year.

At the end of the thermal bar phase in June, lakes over almost the whole basin become stratified. Exceptions are Lake Superior, in which cold offshore pools of water persist well into the summer, and the western end of Lake Erie, which is too shallow to stratify. The water column separates vertically into two more or less distinct layers. A warm upper layer, well mixed by wind action, overlies a cold layer separated from it by a relatively thin interfacial zone—the thermocline—in which temperature decreases (and density increases) with increasing depth.

The thickness of the upper mixed layer (usually about sixty feet) and the mean depth and shape of the thermocline are determined by the fluctuating tide of battle between the vertical fluxes of wind-induced momentum (product of mechanical energy) and of buoyancy (product of thermal energy). This also occurs in small lakes and oceans. But in a large lake the thermocline at any moment is far from level. Turbulent motions below the thermocline are weaker than those in the upper mixed layer and are largely driven by thermocline oscillations. At the same time, the vertical density gradient, in the thermocline interface, virtually cuts the lower layer off from exchange with the upper layer and with the atmosphere. But that barrier is not impassable.

Soon after stratification has become fully established across the open waters of the lakes (in early summer), essential nutrients in surface offshore waters become progressively depleted because algal growth there is limited to the surface illuminated layer and nutrient replenishment from below is impeded at the thermocline. Until recently, most limnologists held the "clas-

Mid-Lake, North-South Temperate Sections

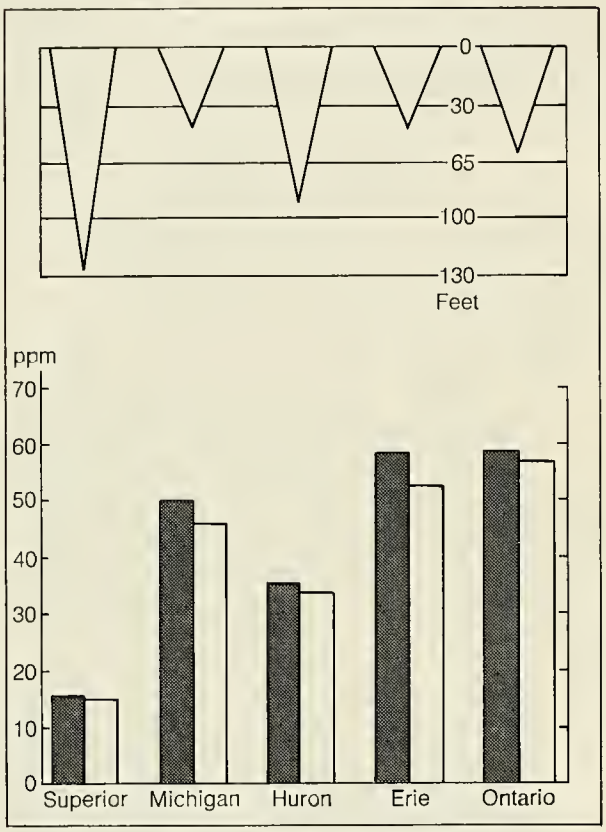


NOAA Satellite Photo

H. Peter Loewer, after G. K. Rodgers

The bars in the lower part of the chart indicate concentrations, in parts per million, of nonnutrient dissolved salts in Great Lakes offshore waters. The shaded bars show calcium, magnesium, sodium, and potassium. The open bars show one-half the sums of bicarbonate, sulfate, and chloride. The cones at the top of the chart indicate the depth, in feet, to which sufficient light is available for photosynthesis. The cones' tapers show decreasing amounts of light.

H. Peter Loewer, after Clifford H. Mortimer



sical" view that nutrient supplies, available in lower layers, cannot be drawn upon until the isolating effect of the thermocline barrier is progressively destroyed in the fall. In fact, elaborate and expensive pollution-effect models, designed for lake management, have been based on this theory.

By slowly lowering a sampling pump through the water column at an offshore station in Lake Michigan, we have recently discovered that there are large concentrations of chlorophyll *a* in layers only a few meters thick just below the thermocline during late summer and fall. The concentrations are sometimes much greater than those usually found at the surface in summer. They are produced by species of phytoplankton, specially adapted to photosynthesize at very low light intensities, that escape the summer starvation in the upper layer by operating below the thermocline in a thin layer into which just sufficient light penetrates from above. The algae in this layer therefore walk a tightrope between nutrient limitation on the upper side and light limitation on the lower.

Production continues until late September when the thermocline has sunk below the level at which sufficient light remains. Until that happens, production in that narrow subthermocline layer nourishes a community of vertically migrating, grazing zooplankton—notably the opossum shrimp, *Mysis relicta*—and also fish foraging in turn upon the grazers. We don't yet know if this active subplay within the larger drama of the whole basin production goes on in other basins—Lake Superior, for example.

After August, the surface layer cools and becomes denser. Winds more easily mix the less buoyant waters. More subthermocline water, with higher nutrient content, mixes into the upper layer, and the thermocline recedes deeper. Finally, an "overturn" in early December destroys stratification and the phase of full winter mixing begins.

After September, as the thermocline descends and the upper mixed layer erodes to successively lower layers, the nutrient concentrations at the surface begin to rise toward their winter maximums. Also the lower layers, previously more or less excluded from contact with the atmosphere, can take a deep breath of atmospheric oxygen.

Phosphorus clearly plays the role of the limiting nutrient, falling below the limits of detection in midsummer. Nitrogen is another universally essential nutrient, and silica is needed by diatom plankton, important as primary producers in lakes. In the large lakes, upward transport of nutrients and downward transport of oxygen are not confined entirely to the season of stratification breakdown. Such transports occur episodically throughout the summer by way of localized "mixing windows" through the thermocline barrier.

The stratified lake—the cold lower layer and warm upper layer—is acted upon by several forces: first, wind applied at the water surface; second, gravity in the form of buoyancy associated with the stratification; and third, the deflective force of the earth's rotation. The two layers engage in a hydrodynamic pas de deux in which the interface between them slowly undulates. The most dramatic up and down flappings occur near shore with upwelling-downwelling motions. These motions are storm induced and, in turn, generate large waves across the whole thermocline blanket.

The phytoplankton community—the "grass" of the system—produces living material by making use of light energy and nutrients. The secondary producers (zooplankton) graze upon the grass and, in turn, provide food essential for young fish and some adult fish as well. Predator fish appear at the apex of the produc-

The lakes generate enough heat in the autumn to retard early frosts in nearby orchards. This orchard, now abandoned, is near Lake Erie.

Robert P. Carr



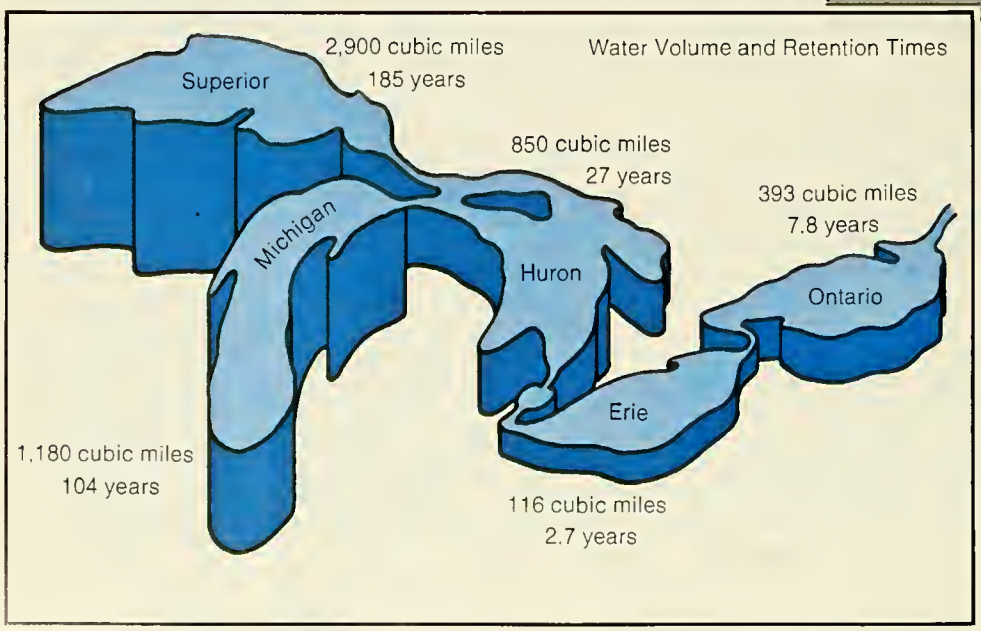
tion pyramid, feeding upon the smaller, plankton-eating fish. All three parts of the food chain interact concurrently. In addition, detritus of the living matter is recycled.

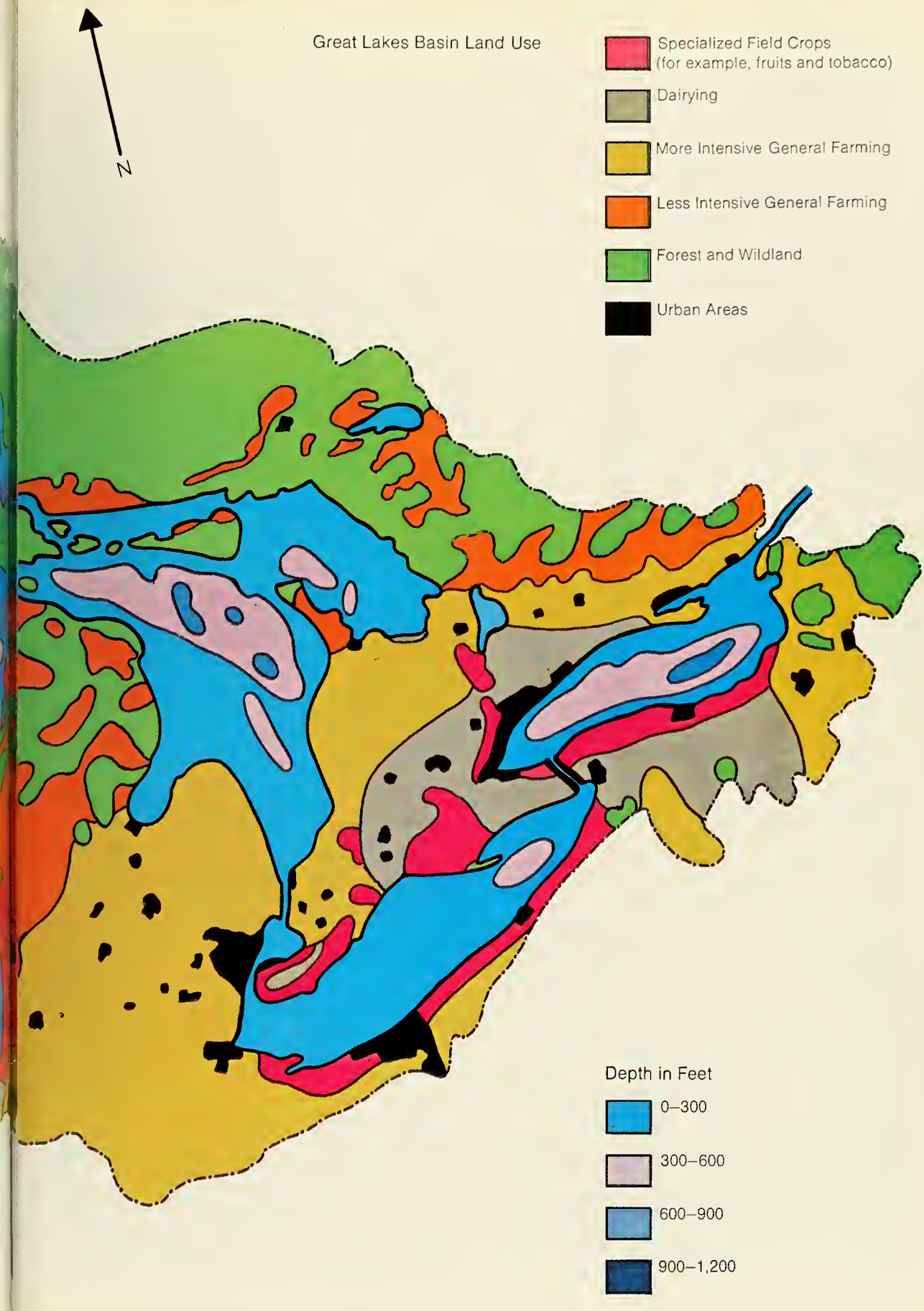
Many steps in the demolition sequence require oxygen. In this, the organic cycles in lakes and oceans do not differ from those on land. Aquatic cycles, however, are often distinguished by some degree of vertical separation of the phases of production and breakdown. This separation is brought about by the combined effects of stratification, gravity, and vertical variation in intensity of turbulent transport, and by the confinement of most primary production to surface illuminated layers.

Water turbulence is strongly suppressed in the density gradient of the thermocline, and thus much of the material entering the demolition cycle sinks through as a continuous "snowfall" to become trapped in lower layers or in bottom sediments. Therefore much of the oxygen-demanding demolition occurs, and most of the regenerated nutrients are released, below the thermocline. The thermocline also bars atmospheric oxygen from the lower layers. The consumption of oxygen below the thermocline can therefore be used to estimate rates of biological production for the whole basin, although sporadic leakages across the thermocline do introduce errors into estimates for large lakes.

When oxygen uptake is used to estimate production intensity, it must be noted that oxygen concentration below the thermocline barrier is determined not only by the rate at which organic matter snows down from above but also by the volume of the subthermocline compartment. Hence, in Lake Superior, with a low production rate and large subthermocline volume, the decrease in oxygen concentration during the stratified season is extremely small. In the central basin of Lake Erie (high production, small volume), the concentration falls to low levels (zero in some places) by mid-August. In the deeper eastern basin, however, the concentration does not fall below 50 percent saturation, although the total consumption is not much less than that in the central basin. Contributing to the heavy

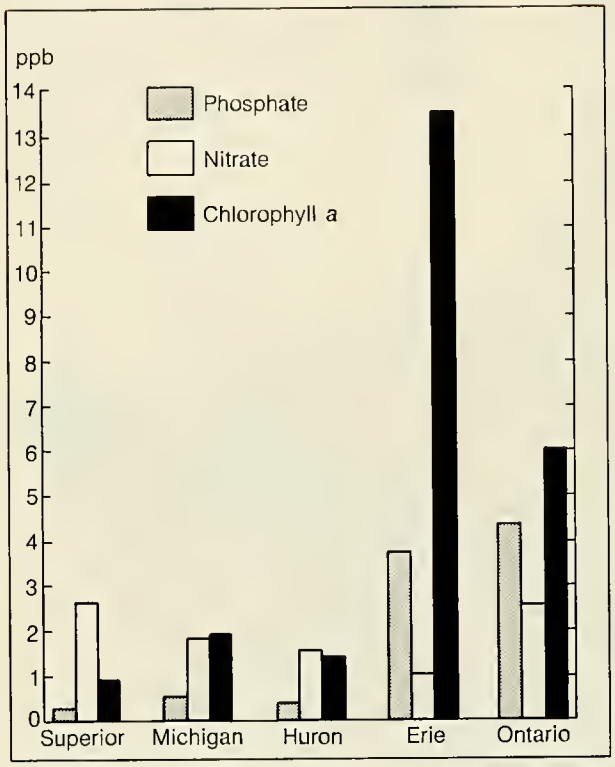
H. Peter Loewer




Great Lakes Basin Land Use
N
Specialized Field Crops
(for example, fruits and tobacco)
Dairying
More Intensive General Farming
Less Intensive General Farming
Forest and Wildland
Urban Areas
Depth in Feet
0–300
300–600
600–900
900–1,200

Concentrations, in parts per billion, of the nutrient salts phosphate and nitrate in offshore deep waters are shown in the shaded and open bars. Dark bars show representative July concentrations of chlorophyll a in surface waters.

H. Peter Loewer, after Clifford H. Mortimer



demand for oxygen in Lake Erie, most evident below the thermocline in the central basin, is massive "blooming" of algae near the surface and subsequent transport of that material through the thermocline to end up in decaying mats on the bottom.

Past records of the oxygen-uptake rate may also be used to document the history of increasing biological production in Lake Erie and other lakes. Lake Erie records show strong correlation with regional population growth and, more directly, with input of the limiting nutrient, phosphorus.

By the measures we have examined here—chlorophyll production and oxygen uptake—Lake Erie is very much alive, despite newspaper reports to the contrary. In fact, for many years the commercial fish catch has been the highest per unit area of any of the lakes, remaining within the range of 16,000 to 29,000 metric tons from 1961 to 1976. However, the species composition has changed dramatically as a result of pollution and the progressive disappearance of subthermocline oxygen in the central basin. That disappearance led to extinction of fish species that lay their eggs in the deep, and other species have had to be withdrawn from the market because of dangerously high levels of chemical contamination (for example, mercury in walleye). However, perch production continued at near-record levels. Overfishing is the probable cause of recent decreases.

In general, the Great Lakes ecosystem has survived quite well despite the various and sometimes conflicting uses humans have made of the lakes' resources. The play has changed and some actors have left, but there has been an encouraging resilience in the show's response to various threats to its continuance. One example is the flourishing sport fishery based on artificial introduction of predator fish replacing the original stocks lost to lamprey depredation. In recent years, however, one particular threat has emerged, against which the large size and biological resilience of the lakes may be no protection. That threat, which looms larger every year, is the introduction of man-made poisons. The effects, only partly known and controlled, are potentially far more devastating than nutrient pollution or addition of waste heat from electric power stations. Indeed, additional fertility or heat sometimes increases fish production, as exemplified by Lake Erie, the Green Bay arm of Lake Michigan, and other polluted regions.

But what profit is there in higher production if the fish are too contaminated to eat or if the gene pools of valuable species have been lost forever? The swelling tide of diverse interactions between chemical technology and the aquatic environment is a relatively recent phenomenon. Although much chemical contamination occurs at very low concentration levels, the frightening features of these developments are persistence, that is, very slow breakdown rates in the aquatic environment; accumulation in particular links of the biological chain, for example, predator fish; and the introduction of new compounds every year.

The most important questions before us are, Can we devise effective early-warning systems to detect where the blows are coming from, and can we find ways to ward them off? The urgent task is to apply our collective and, in the case of the lakes, binational inventiveness not only to progress in chemical and other technologies but also to progress in prediction and control of the repercussions of that inventiveness on nature. Some parts of this chain of inland seas called the Great Lakes are more affected and more threatened than others. But local damage reverberates in other places and at other times. A precious natural resource will be diminished and may even be destroyed for future generations unless an awakened and educated public insists upon, and is willing to pay for, enlightened public planning and management now. □

The Blue-Green Algae Keep Coming

Lake Superior is the last stand for some microscopic floras that were once found throughout the lakes

by Eugene F. Stoermer

The conclusion that "Lake Erie is dead," which we have been hearing for almost a generation, tells us more about the speaker's point of view than about the subject. From a narrow, strictly technological perspective, the statement is wrong: Lake Erie today is measurably more productive of living material than it has been for many years. But the environmentalist's broad perspective sees an ecosystem such as a large lake as analogous to a living organism and leads him to conclude that Lake Erie is "dead" in the way that an organism that has lost several vital functions is dead. To the environmentalist, survival of large ecosystems depends upon the retention of their functional integrity.

In the case of the Great Lakes, several primary and vital functions of the ecosystem have undergone significant alteration. Of these functions, the most basic is the production of phytoplankton, the microscopic algae that are the first link of the food chain, which leads through zooplankton to the lakes' fish and, eventually, to human populations. This algal flora is to the lakes what grass is to the prairie: it converts the radiant energy of sunlight and mineral elements into organic products that are used by higher organisms. Conditions that affect the life processes of algae must eventually affect other organisms.

Once a high-quality and almost perfectly exploitable system, the Great Lakes have undergone progressive degradation in the past three hundred years. When we consider that Europeans have been present in the region for that time, our understanding of the lakes' fundamental properties is surprisingly primitive. One reason for this is that logistical problems hindered research. The lakes are huge and subject to dangerous storms. Scientists wishing to work on them faced, at best, a very expensive and, at worst, an occasionally unpleasant task.

Another reason is that even when resources were available, people tended to study a problem alone, rather than its fundamental cause. Only during the past thirty years, when certain problems reached catastrophic levels, have funds become available to mount the comprehensive investigations necessary to study these inland seas.

Thus our understanding of the basic characteristics of the Great Lakes is based partly on reconstruction of past states. Scientists are sure, however, that several physical characteristics of the lakes have affected the algal flora. Originally, the lakes' waters were as pure as rainwater. This was because the lakes' drainage is small compared to their surface area and because much of the basin is composed of bedrock types that are highly resistant to leaching—the igneous and metamorphoric rocks of the Canadian Shield. Very poor in dissolved salts, the lakes' water quality was nearly that of distilled water. Of the major nutrients essential for algal growth, only nitrogen was present in excess. The waters were originally poor in silica and, especially, in phosphorus. The term "oligotrophic" well describes the nutrient-poor, oxygen-rich state of the pristine Great Lakes.

Another characteristic of the lakes—perhaps the most striking—is their sheer physical mass. Taken together, they constitute one-fifth of the total standing freshwater on the earth's surface. One consequence of this great mass is that the lakes have a tremendous heat-storage capacity, which causes their heating and cooling to lag considerably behind heating and cooling of the surrounding land. The cooling effect of the water delays spring flowering in orchards and vineyards until after the last frost, and the warming effect of these liquid heat engines retards the autumn frosts and permits fall fruit maturation. Similarly, evaporation given up during the winter creates the great snow belts around the lakes.

More significant for algae, this heat-storage capacity restricts the dispersal of nutrients in two ways, each closely related to water temperature. One mechanism for the restriction of nutrients is the springtime thermal bar, a barrier created by the convergence of cold and warm water. Freshwater reaches its maximum density at approximately 40°F. During the spring, the nearshore waters are warmed to above the temperature of maximum density, while the great mass of deep offshore water is below the temperature of maximum density. At the convergence of these water masses there develops a narrow zone of maximum density water, which sinks and, like a curtain, separates the two water masses. This curtain—the thermal bar—restricts to the shoreline materials fed to the lake by streams during the early spring growth period.

The lakes' heat-storage capability also constrains mixing during the summer. In the past, the few minerals that existed in offshore waters were taken up by phytoplankton, which then settled during the summer months to the cold, dense level, about 60 feet deep, called the hypolimnion. The surface waters—the epilimnion—were warmed considerably in the summer and tended to float on the hypolimnion. Light penetrated through the lakes' highly transparent waters to the upper part of the nutrient-rich hypolimnion, where plant growth was stimulated. Light, temperature, and nutrient conditions in this zone remained comparatively stable throughout the entire year.

Another significant characteristic of the Great Lakes

region is its relative youth. The Laurentian Great Lakes were formed only about 10,000 years ago, during the last retreat of the Pleistocene glaciers. By comparison, Lake Baikal, in the Soviet Union, is probably 50 million years old. Thus, the Great Lakes' organisms have not had the time to become highly adapted to their environment. They lack the resiliency to environmental perturbations that is typical of organisms in more ancient bodies of water.

Finally, the location and shape of the Great Lakes have influenced the algae populations. North to south, the basin lies across the boundary between two major climatic regimes, extending from the lower margin of the northern boreal forest into the upper part of the humid temperate region. The lakes extend the geographical range of boreal organisms into the temperate climates. Because of their thermal characteristics, the lakes also furnish an extension of temporal range of certain populations adapted to the low temperatures of the Pleistocene climate. The lakes' east to west orientation was an invitation to early settlers, providing water transportation to the rich natural resources in the Midwest. This combination of accessibility, onshore natural resources, and clear water led, in turn, to concentrations of industry and populations—which fed their wastes right back into the lakes.

Those characteristics produced a distinctive set of algal assemblages. As best as can be reconstructed, the dominant phytoplankton in the offshore waters of the Great Lakes were particularly well adapted to conditions of low levels of nutrients, relatively cold water temperatures, and limited light. The most abundant type of algae were diatoms, which were favored by the low temperature and the low phosphorus level. Unlike other plants, diatoms are dependent upon silicon dioxide, which forms their walls. The diatoms were extremely diverse; the number of species in the Great Lakes was approximately the same as the number of species of vascular plants growing on the surrounding shores.

As far as we know, these planktonic floras, free floating throughout most of their life cycles, were quite similar in offshore waters throughout the lakes, despite some differences in water chemical conditions. Some areas were more productive than others, and differences between nearshore and offshore algal flora were due to differences in nutrient loadings. Large, shallow embayments—western Lake Erie, Lake Huron's Saginaw Bay, Lake Michigan's Green Bay—all tended to have floras similar to those found on smaller lakes, with their nutrient-rich streams and shallow water readily mixed by wind action. These embayments produced a great many primary producer organisms and, in turn, many fish. The fish encouraged human settlement.

As long as the nutrients stayed close to shore, offshore algae levels and types remained quite stable. In the winter, the mid-lake water temperature was at or below 40°; consequently, there was some mixing between levels. Since the organisms in this water mass had a good chance of being carried below the depth of effective light penetration, winter survival depended upon their ability to survive limited light. During the summer, they also lived in deep water, so in a way, the hypolimnion was a year-round refugium for Great Lakes algae and provided a constant food base for other organisms as well.

This rather conservative system seems to have prevailed until the incursion of nutrient pollutants—especially phosphorus—into the middle of the lakes. The addition of large amounts of phosphorus, which is what scientists call a limiting factor because it is so important to growth in the lakes, stimulated algal growth and, consequently, algal uptake of other nutrients. Eventually, the available silicon was depleted, and the competitive advantage switched from diatoms to physiological groups that do not require silicon for growth, such as green and blue-green algae during the summer.

When phosphorus loadings increased further, nitrogen levels in the water diminished. At this point blue-green algae, which alone can utilize nitrogen from the atmosphere, developed a great advantage over algae that drew nitrogen from the water. This explains the rapid enlargement of the algal biomass at the surface and the change from diatom to blue-green algal dominance. Large populations of blue-green algae are generally undesirable because they produce nuisance blooms and are poor food sources for zooplankton.

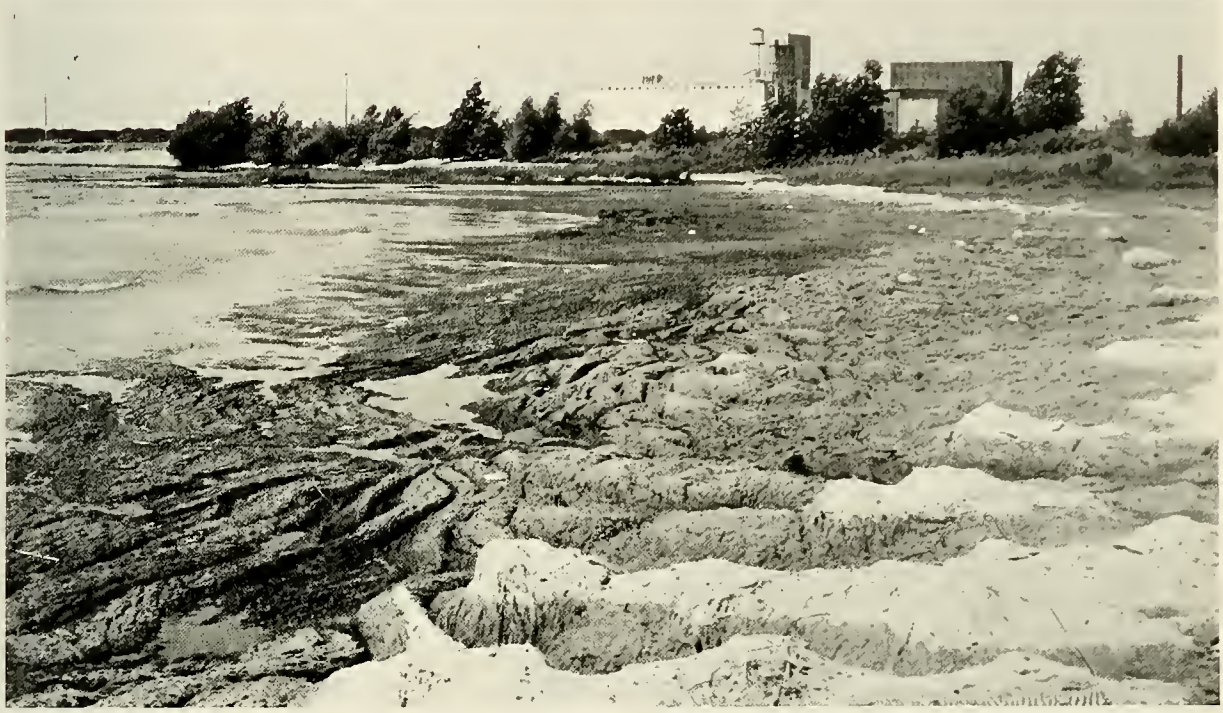
As the surface became more densely populated, water transparency was reduced. Eventually, the deepwater refugium in the upper part of the hypolimnion became so shaded that the indigenous diatom population could no longer survive. Zooplankton populations feeding in the epilimnion prospered at the expense of deepwater species as a consequence of this change in the food base. This change, in turn, favored invading fish species, such as the alewife, at the expense of the indigenous chub, cisco, and lake herring.

The conservative system that had prevailed, with algal productivity taking place almost constantly through much of the water column, was now replaced by a seasonal cycle of blooms and crashes—massive die-offs—of surface algal assemblages.

Exotic populations have also increased at the ex-

An algal bloom on Lake Erie's Nickel Beach

P. H. Davies; Bruce Coleman



pense of the indigenous species as levels of sodium, chloride, and sulfate have increased in the water. At present, we cannot accurately evaluate the effects of these changes against the background of the very large modifications resulting from nutrient pollution. They are, however, of concern since these nutrients are not removed from the water to an appreciable extent by biological activity. Once introduced to a system they remain until flushed out.

The lakes most affected by this major alteration in algae populations are Erie and Ontario. Both have lost significant elements of their indigenous flora, replaced by large populations of species that thrive under high nutrient loadings and some degree of salinification. Lake Michigan is in transition; although severe nutrient imbalance occurs there during summer stratification, some indigenous populations still exist in this lake's offshore waters. Some of the populations that dominate in Lakes Erie and Ontario now have a foothold in Lake Michigan's nearshore waters. Northern Lake Huron has undergone only slight modification, in part because of nutrients transported from Lake Michigan, but the flora of the southern half of Lake Huron is substantially modified as a result of materials arising from Saginaw Bay, one of the most highly disturbed regions within the Great Lakes system. Lake Superior is the last stand of some of the extremely sensitive organisms once found throughout the lakes. Local areas in Lake Superior, such as the Duluth embayment, now contain many of the blue-green species found in the lower lakes.

Because of its relatively small volume, Lake Erie's nutrient loading problems may be the easiest to solve with current technologies. Reversing the trend toward salinification may prove more difficult, however. It is doubtful that Lake Ontario's conditions can be improved under currently envisioned control measures. Lake Michigan is at a very critical stage, and its future will affect that of Lake Huron, into which it flows. Lake Superior is the least modified of all the lakes, but it is quite possibly the most fragile system.

The current efforts to limit phosphorus inputs to the lakes by improving sewage treatment and reducing the phosphorus content of detergents or banning them entirely will undoubtedly help reverse the trend of water-quality degradation in the lakes. Some of the effects of these actions are just now becoming apparent. However, the modifications of the system that have resulted from long-term misuse will not be immediately undone. □

The Bald Eagles Return

A higher birthrate and new management techniques justify guarded optimism about the bird's future

by Sergej Postupalsky

Before man altered the environment, a pair of bald eagles inhabited every five or ten miles of Great Lakes shoreline. This population density held for the south shore of Lake Superior until as recently as twenty-five years ago, but today no more than two dozen pairs of bald eagles remain along the entire Great Lakes shoreline. They are about equally divided between Lakes Erie and Superior, where an encouraging increase in reproduction appears to have begun about seven years ago.

To maintain their population, bald eagles must produce, on the average, a minimum of 0.7 young per pair each year. But for many years this rate of reproduction was not reached, except in the western part of Michigan's Upper Peninsula in some years in the 1960s.

As an ornithologist, I found the study of bald eagles extremely frustrating until recently. In late winter or early spring, I would observe the eagles return to their aeries and refurbish them with new sticks and grass. In March and April, I would see one of the pair sitting low in the nest, apparently incubating eggs. By late April or May, however, the adults would be gone, leaving no young in the nests. This fruitless cycle was repeated year after year. One after the other, the breeding sites were deserted as the old eagles died off and no mature birds took their place.

This pattern was more pronounced near the Great Lakes. While from 37 to 66 percent of pairs nesting on inland lakes, reservoirs, marshes, and rivers were able to raise young, only about 10 percent of pairs occupying aeries near the Great Lakes produced eaglets.

The onset of reproductive failures, which affected other raptors and fish eaters besides the bald eagle, coincided with the introduction of the pesticide DDT after World War II. The unrestricted dispersal of this compound led to its accumulation in many of the world's ecosystems, especially in aquatic ones. Although its use in the United States had declined well before it was banned in 1972, DDT greatly affected the bald eagle because of the bird's longevity and its position as the terminal link in a long aquatic food chain. Although no pesticide data for recent eagle eggs are available to test whether the improving nest success is attributable to decreasing contamination, several studies show that residues of DDT and its metabolites (breakdown products) have been declining in some birds and in Great Lakes fish. Still, the U.S. Fish and Wildlife Service reports no decrease in pesticide burdens in dead bald eagles through 1974.

Not until the late 1960s was the precise cause of reproductive failure identified. Although DDT had been a prime suspect all along, more than two decades of painstaking research demonstrated that it was DDE, a metabolite of DDT, that interfered with the formation of eggshells in the female bird and caused her to produce eggs with abnormally thin or soft shells. The more DDE in the female's system, the thinner the shells she produced. These shells usually cracked or were crushed during incubation. The extremely thin-shelled bald eagle eggs from the Great Lakes aeries were found to be heavily contaminated with DDE, as well as other pollutants. Scientists were therefore not surprised at the near-zero breeding success of bald eagles nesting closest to the Great Lakes, the bodies of water containing the most DDT.

The ratio of 0.7 fledged young per pair was attained or exceeded by bald eagles in Michigan's Upper Peninsula in eleven of the last seventeen years. Eagles in the state's Lower Peninsula consistently produced below this level until 1970 and above it since then. More recently, the Lower Peninsula's bald eagle population has increased slightly, from fewer than two dozen pairs to the twenty-six pairs identified in 1977. At least eight new pairs of eagles have become established since 1974 in parts of Michigan where bald eagles had not nested for more than a decade. There were eighty-seven pairs of eagles in Michigan in 1977. Still, reproduction has been spotty in the narrow eastern portion of the Upper Peninsula.

The first indication of recovery of the species near the Great Lakes occurred in 1971, on Lake Erie's Canadian shore. In the past seven years, more eaglets have been raised there than in the preceding decade, even though fewer pairs have been present recently. On the Ohio side of Lake Erie, after a hiatus of two years during which no eagles fledged, between one and three young have been reared annually since 1973. Nevertheless, the population of approximately ten pairs of bald eagles at the western end of Lake Erie is one of the most endangered groupings of the species. At least three adult eagles have been shot on the Ontario side of the lake in recent years, and three adults are known to have been electrocuted on power transmission lines on the Ohio side since 1974. A small, isolated population cannot sustain such attrition of breeding-age birds much longer as dead mates are almost impossible to replace.

No signs of improved nesting success were noted at Lake Superior until 1977, when five nests on the south shore produced a total of six young. One breeding site had young last year for the first time in at least seventeen years, even though a pair had been present every year and had attempted breeding in most years. In 1969 the remains of a shell-less egg were found in

this pair's nest, and in 1970 the same nest contained an intact egg with a shell nearly 40 percent thinner than normal, pre-DDT eagle eggs. These developments, although encouraging, do not mean that the bald eagle is now out of danger in the Great Lakes. I suspect that most, if not all, of the successful 1977 nesters were young females raised in the interior, where DDT has had considerably less effect than on the Great Lakes. Most occupied Lake Superior eagle nests are situated near the healthy interior population in the western Upper Peninsula of Michigan and in northern Wisconsin. Will these birds continue to breed successfully after they have fed on Great Lakes fish for an extended period of time?

The bald eagle's gain in population since the banning of DDT justifies guarded optimism about the species' future in the Great Lakes area and elsewhere. To be sure, other factors, once overshadowed by the "thin eggshell syndrome," continue to affect the eagles—especially man-caused mortality and the development of lakeshore habitat for human uses. Now that the threat of DDT appears to be abating, management efforts must concentrate on preserving and enhancing sufficient breeding habitats to perpetuate healthy, growing eagle populations. At the same time, we must remain alert to the effects of toxic substances released into the environment.

The provision of artificial nest structures is one of several promising techniques available to wildlife managers. We have known for several years that bald eagles will use such platforms, which were accepted recently in Michigan, Wisconsin, Arizona, and Idaho. But it was not until the summer of 1977 that successful nesting by bald eagles in man-made nests was reported —five eagles fledged from two platforms in Michigan.

The success of man-made nests opens up several possibilities for nest-site manipulation. Artificial nests may prove useful as replacements for structurally weak nests, allowing pairs to remain in good breeding areas even when natural sites are at a premium. They may also attract new pairs to suitable, but currently unoccupied, breeding habitats and to other places lacking natural nest sites. In addition, the chances of successful nesting may be improved by moving nests that are exposed to human activity to secluded sites nearby.

Other manipulative management techniques have been tried with the bald eagle. Captive-bred nestlings have been released into endangered populations through fostering to wild pairs or through the hacking technique of falconry. Eggs have been transferred from healthy populations to nests of contaminated, nonproductive pairs; injured and rehabilitated eagles have been released; and uncontaminated food has been provided in the winter. At least some of these techniques hold promise for the recovery of the bald eagle of the Great Lakes. □



Vic Banks





Leonard Lee Rue III; Bruce Coleman

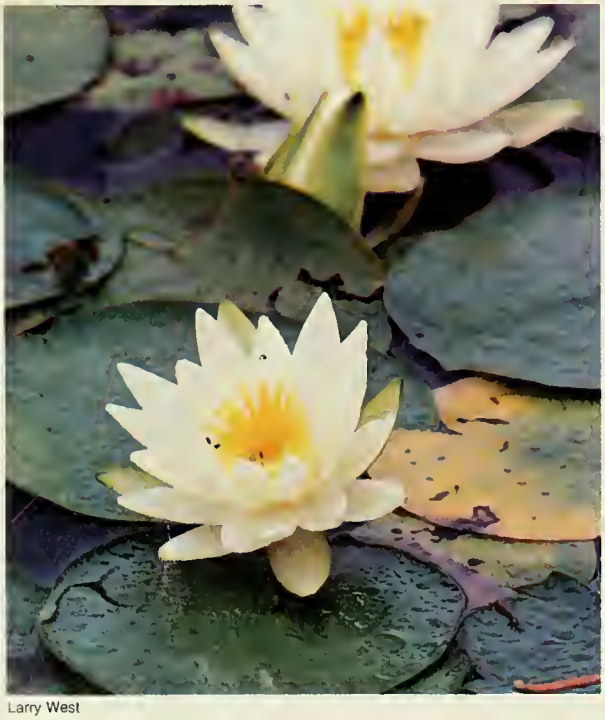
Clockwise from upper right: The flowering rush, arrowhead, white water lily, and cattail have all been seen in Put-in-Bay harbor, but only the flowering rush is common today.



Michael Smith, Photo Researchers



Jeanne White, Photo Researchers



Larry West



Larry West

The Decline of Lake Plants

Human activities over the past eighty years have contributed to a 50 percent decrease in the aquatic flora of an Ohio harbor

by Ronald L. Stuckey

At their present state of knowledge about aquatic flowering plant species composition, botanists cannot make definite statements about the causes of changes in lake flora. The best we can do is analyze probable causes. We can, however, be considerably more definite in measuring these alterations. Eighty years ago, forty different aquatic flowering plants flourished in Put-in-Bay harbor, in western Lake Erie, then one of the most diverse communities of these plant species in the United States. Today, only half these species survive, and of these, several are rare and in danger of disappearing from the harbor altogether.

Scientists can analyze the changes and trace the decline of aquatic flowering plants in the Put-in-Bay area because of existing historical records. Dried specimens of these plants have been preserved in museums and herbariums for the past eighty years. Together with associated data from the area, these specimens make up one of the most complete records of aquatic flowering plants for a given locality in North America.

Among the first comprehensive surveys of aquatic flowering plants in the United States were those made in western Lake Erie in 1898 by Adrian J. Pieters, as part of the United States Fish Commission's investigation of the biology of the Great Lakes. Pieters did his most thorough fieldwork at Put-in-Bay; as the headquarters for his survey, it was the most accessible of the several areas that he studied. His paper "The Plants of Western Lake Erie, with Observations on their Distribution," published in 1901, is regarded by botanists as a classic.

A contemporary of Pieters, a high school science teacher named Edwin L. Moseley, recorded the plants of western Lake Erie and Put-in-Bay harbor. In the twentieth century, several botanists have studied the aquatic flowering plants at Put-in-Bay. During the summer months of 1967 through 1970, I conducted fieldwork at Put-in-Bay, and by comparing the results of my work with the record assembled by Pieters, Moseley, and others, I was able to trace the change in the abundance of the aquatic plant species over the previous seventy years. During the past ten years, the aquatic flora has changed very little in the area studied.

Put-in-Bay harbor is a semicircular inlet on the north shore of South Bass Island, Ohio, which is four miles offshore, about halfway between Cleveland and Toledo, Ohio. The harbor is protected on the north by Gibraltar Island, which reduces wave and wind action from that direction, and is divided into three subinlets—the main harbor, Squaw Harbor, and Fishery Bay. A small body of water called Terwilliger's Pond extends inland from Fishery Bay.

My study indicates that since Pieters's work, drastic changes have occurred in the aquatic flowering flora at Put-in-Bay. Pieters reported forty species of submersed, floating-leaved, and emersed rooted plants. Of these, eight were never reported in later surveys, and by 1949 fourteen species had disappeared. Twenty species remained in the 1967–70 survey, but only one of these is considered to be abundant. Of the remaining nineteen, nine are considered to be rare (few in number at one or two study sites); eight are occasional (few in number at three or more sites); and two are common (in large numbers at most sites). Comparison of the present information on abundance for each species with data given by Pieters in 1901 shows a gradual decrease in abundance for the surviving species.

Descriptions of Squaw Harbor by several botanists summarize the changes that have taken place in Put-in-Bay's flora since the turn of the century. Pieters wrote: "The bottom of this bay varies much, being stony in some places and muddy in others. The water is turbid, and it is usually impossible to see plants more than two to three feet below the surface.

"Squaw Harbor is bordered by a narrow strip of rushlike plants. These plants are limited abruptly on the land side by the rocks and on the other side by a depth of from 2 to 2.5 feet of water. Toward the east *Sagittaria rigida* [rigid arrowhead] forms a prominent group, extending about thirty feet from the shore and finding its limit of depth in about 2.5 feet of water. . . . This species also occurs on the other shore with *Scirpus lacustris* [*S. acutus*, hard-stem bulrush], but is not as abundant as on the east side." Of the original forty species at Put-in-Bay, Pieters noted twenty-nine in Squaw Harbor.

In 1934, Lewis H. Tiffany wrote that the water in Squaw Harbor was shallow and much protected from winds and might become choked with aquatic plants in late summer. Fifteen years later, in 1949, Earl L. Core noted that the mud bottom in Squaw Harbor continued to slope gradually and was "still covered with a dense mass of vegetation." He also noted an appreciable increase in turbidity and further observed that "the shores of Squaw Harbor are now almost completely lined with boat docks and more continue to be built. This has almost eliminated the narrow strip of rushlike plants that fringed the shores in 1898. Only occasional plants of *Scirpus validus* [soft-stem bulrush] and *S. americanus* [three-square] still occur. *Sagittaria rigida* . . . has now apparently completely disappeared . . . [It was] present as late as 1940 [but] its disappearance may have been partly due to the high water of 1943–48 and partly due to increasing activity about the numerous docks in the locality. . . . *Carex comosa* [sedge] has likewise disappeared. . . . The 'thick growth' of *Dian-*

thera [*Justicia*] *americana* [water willow] along the south shore has completely disappeared." Still, various submersed species remained abundant.

Finally, my fieldwork revealed that even the submersed species had declined considerably in Squaw Harbor. Core had noted thirteen species, but I could find only seven of them. Small colonies of seven emersed species along the shoreline that were present in 1967 had disappeared by 1970, following a sudden rise in lake water level and increased boat traffic.

Botanists' records tell the same story about the plants in the main harbor and Fishery Bay. In 1949, Core wrote of the main harbor that "almost nothing grows in this area today, perhaps because of the increased turbidity and activity of boats." By the late 1960s, few plants were found at all in the main harbor. In Fishery Bay, Core wrote, plants "are now scattered in patches, the location of which apparently varies from year to year. No significant difference was noted in the inventory of species, which Pieters reported. . . . However, Pieters recorded those species as 'abundant' or 'common' in 1898, whereas they can scarcely be so regarded at the present time, except near the shores." Although there were two newcomers to Fishery Bay since 1949, abundance and number of plant species were reduced by the time of my own fieldwork in the late 1960s.

Several environmental conditions may be responsible for changes in the aquatic flowering flora at Put-in-Bay. One is the effect of high water. Records of the water levels of the Great Lakes show that Lake Erie's level fluctuates from two feet to four feet about every ten years. If aquatic plants are sensitive to these changes in water level, then we should see changes in species composition and abundance over time. Those species that are tolerant of a sudden rise in water level have mechanisms that allow them to survive during high water. For example, the flowering rush (*Butomus umbellatus*) changes form. On a mud flat, it is a stout, erect plant with many bright pink flowers. Submersed, it remains a vegetative plant, with limp, three-angled leaves, which does not flower. The white water lily (*Nymphaea tuberosa*) and the yellow spatterdock (*Nuphar advena*) grow longer petioles in response to high water levels, thus enabling their broad leaves to float on the water surface or project above the water surface, respectively. On the other hand, cattails (*Typha angustifolia, T. latifolia*), common arrowhead (*Sagittaria latifolia*), and bur reed (*Sparganium eurycarpum*) are drastically affected by a sudden rise in water level; a rise of as little as one or two feet can partially or totally eliminate them from a pond or marsh. They apparently have no vegetative mechanism to allow for survival in deep water. The disappearance of certain species during high-water times is usually only temporary, and when water levels go down, exposing shorelines and mud flats, these species will return, having survived as seeds in the mud and sediments for many years. The dynamic and fluctuating water-level conditions that occur in the Lake Erie marshes provide a major explanation for the great diversity of species there, compared with natural inland lakes and inland marshes, which have more stable water levels.

Changes in water temperature also appear to affect aquatic flora. Of the twenty species no longer present in Put-in-Bay harbor, eleven occur principally in cool-water habitats mostly to the north of Lake Erie. Of the twenty species identified by Pieters that still survive in the harbor, fourteen have widespread distributions, extending both to the north and to the south of Lake Erie, as well as throughout the eastern United States or North America. The northern species apparently are less tolerant of the warmer water conditions that have developed recently, especially in the shallow bays, than are the widespread species. Of the eleven northern submersed species inventoried by Pieters, only one, Richardson's pondweed (*Potamogeton richardsonii*), survives at Put-in-Bay.

Another significant cause of the decline in Put-in-Bay's submersed flora is the increased turbidity of the water. Pieters noted in his 1898 study that the water in and around the harbor was less clear than that of other sampling sites. One writer, who worked at the harbor in the early 1940s, pointed out that many of the rows of vineyards on the island were laid out in the same direction as the slope of the land and perpendicular to the shoreline. This layout, along with cultivation between the rows, facilitated extensive erosion. A local newspaper noted in 1898, the same year that Pieters did his survey, "that there was no end of complaint about mud and water standing ankle deep in the vineyard rows"—mud that made its way into the water of the harbor. In general, the more turbid the water, the less effective the penetration of light, which in turn retards photosynthesis to the extent that the plants do not produce enough food to live.

In the late 1930s and early 1940s, Bernard S. Meyer and his students studied the relationship of turbidity, depth, and apparent photosynthesis in six selected submersed species in western Lake Erie's island area. They measured the compensation point—where no net photosynthesis occurs—and found that with continued turbidity through the years, the compensation point remains close to the surface. Consequently, plants with high light requirements will not produce enough food

and eventually will die. A comparison of the results of their studies with the present abundance of these same six species in Put-in-Bay harbor showed that over the years increased turbidity—due to erosion, dredging, and shoreline construction—has caused the reduction or elimination of those species, such as flexed naiad (*Najas flexilis*) and waterweed (*Elodea canadensis*), determined by Meyer and his students to have shallow compensation points and high requirements for light. Conversely, wild celery (*Vallisneria americana*) had a compensation point below thirty feet, meaning that it could carry on photosynthesis in dim light and grow at the greatest depths. Of the original forty species, it is by far the most abundant species in the bay.

My work at Put-in-Bay also suggested that turbidity may be a limiting factor. In 1967, Terwilliger's Pond, which is connected to the harbor by a narrow inlet from Fishery Bay, had five submersed species in the shallow water along the northwest bank. These species were still there in the summer of 1968, but in greater abundance and in the company of three additional species. At the pond's west end, which had shallow, relatively clear water, no submersed species were present in 1967, but I found five in 1968. However, with the one- to two-foot rise in Lake Erie's water level in the summer of 1969, considerable erosion occurred along the south bank of the pond. By the summer of 1970, at least two feet of the bank had washed away, causing increased turbidity in the pond's water. I found no species of submersed aquatic plants anywhere in Terwilliger's Pond that summer.

Besides high water, warmer water, and water turbidity, other reasons for the reduction and elimination of aquatic flowering plants at Put-in-Bay are the decreased oxygen content of Lake Erie and man's increased use of the harbor for recreation. The first factor is well documented. Many of the northern species that are especially sensitive to warm water and turbidity are also more tolerant of well-oxygenated ponds and lakes than of the eutrophic conditions frequently found in Lake Erie during the summer.

The effect of human activities on the Great Lakes is becoming better known, and Put-in-Bay, which has become a major resort town, has been particularly affected by cultural change. Many tourists arrive by sail and power vessels; consequently, the harbor is now lined with docks to accommodate them. Continued and increasing use of motorboats tears and uproots submersed plants. Exhaust gases and engine oil, as well as sewage dumped into the water, have detrimental effects on the plants. The harbor has been dredged in many places to permit access by larger boats and retaining walls have been constructed along the shoreline. Formerly ideal shallow-water habitats, with bottoms gradually sloping from the shore to deep water, have been virtually eliminated and replaced with deep, muddy channels. Aquatic species with narrow ecological tolerances and with distribution limited to these once-shallow, once-less-turbid areas have been destroyed. But other species with wider ecological tolerances have survived or colonized in areas more disturbed by man's actions.

The depletion of flowering aquatic plants at Put-in-Bay is well illustrated when compared with the flora of the ponds on Lake Erie's islands. Based on the original records, thirty species of submersed, unattached floating aquatic flowering plants occurred in Put-in-Bay harbor and the isolated ponds on the islands. Five species were common to both habitats. Of the ten species that were restricted to the isolated ponds, all continue to survive there today, whereas only five of the fifteen that were restricted to Put-in-Bay continue to survive. In other words, of those ten submersed species that have disappeared from the area, all inhabited only bays. The ponds that still survive are essentially the same today as they were eighty years ago, influenced by humans, at most, by surface wash from adjacent cultivated fields. By contrast, it is evident that the changes brought about by human activity in Put-in-Bay harbor have had a profound influence in bringing about the decline of the submersed aquatic flora.

Similar changes have occurred at another northern United States lake, Lake East Okoboji, Iowa, where twenty-six of forty-four species identified in a 1915 study had disappeared by 1961. The reduction in the submersed species was, as at Put-in-Bay, especially striking, for of twenty-three species, eighteen were lost. The botanists who did the 1961 fieldwork identified several causes for the lake's loss of plants, among them, intense use of the surrounding land for agriculture and other exploitation of the lake and its shores. These human activities led to increased siltation, turbidity, and nutrient content in the water. Comparisons of 1922 studies of the plant life in University Bay, Lake Mendota, Wisconsin, with 1966 studies indicate that although conditions there apparently are not as drastic as they are in Lake East Okoboji or at Put-in-Bay, similar conditions could develop. The pattern may repeat itself: species of aquatic flowering plants whose ecological tolerances are narrow will mostly disappear as clear, cool, well-oxygenated water becomes turbid, warm, and poorly oxygenated. Such changes should be taken as warnings if man intends to maintain high diversity in the flora of lakes and bays. □

Pollutants from the Sky

Airborne toxic elements are one of the biggest—and most baffling—problems for the lakes

by Jon I. Parker

Among the most important and least understood pollutants of the Great Lakes ecosystem in the past century are trace elements from atmospheric fallout. Trace elements—chemical elements, such as mercury, cadmium, copper, zinc, and lead, that are present in the water at extremely low concentrations—may be highly toxic to aquatic biota. Some trace elements, such as zinc, are essential for the normal metabolism of biota, but the margin between required and toxic levels is frequently narrow.

Wind-raised soil dust, automobile exhausts, and cement and steel manufacturing all contribute trace elements to the atmosphere. However, the combustion of fossil fuels, particularly coal, probably is the major anthropogenic source of atmospheric trace elements to the Great Lakes. Coal-fired power plants presently provide about 80 percent of the basin's fossil fuel generating capacity. Increasing demands for electricity and a greater dependence on coal as the major powerplant fuel suggest that trace element pollution in the Great Lakes will increase.

Some of the trace elements from combustion, such as mercury, cadmium, and copper, can kill aquatic organisms at concentrations of several parts per million parts of water and cause more subtle effects at lower concentrations. Planktonic algae suffer reduced photosynthetic rates and planktonic animals show reduced reproductive capacity at trace element concentrations in the parts per billion range. These responses could result in undesirable changes in species composition in the lakes. For example, the level of copper in Lake Michigan exceeds the toxicity threshold for certain types of freshwater algae. Algal microfossils from the sediment of Lake Michigan show that dramatic shifts have occurred in species composition during the past one hundred years—possibly because of the toxic effects of trace elements.

In addition, some combinations of trace elements behave synergistically, that is, an organism's response to a mixture of elements is greater than the sum of its responses to the individual elements. While the present concentration of any single trace element in the Great Lakes may not be hazardous, the cumulative effects of all trace elements may be causing subtle impacts. Furthermore, a few trace elements, for example, mercury, accumulate in the tissue of aquatic organisms. Predators may concentrate large doses of toxic materials by eating contaminated prey. Some fish have become so affected by mercury and other toxic substances in lake waters that restrictions on human consumption have been imposed.

In coal-fired power plants, trace elements are mobilized during high temperature combustion. About 70 percent of many trace elements is partitioned to the flue gas; less than 30 percent goes to the solid wastes. Efficient collection devices, called electrostatic precipitators, can remove 95 to 99 percent of the fly ash, along with its adsorbed trace elements, from the flue gas. The collected fly ash is subsequently diverted back into the solid waste. A small fraction of the trace elements escape to the atmosphere as vapors and as constituents of the microscopic fly ash particles that escape collection.

The solid wastes—bottom ash, boiler slag, and fly ash from the precipitators—and sludge from flue-gas desulfurization equipment, called scrubbers, frequently are sluiced (with water from the power plant) into ash disposal ponds. Sometimes water in the ponds, highly enriched with trace elements leached from the solid wastes, seeps through the pond wall or is discharged into local waterways. In one case, pond effluent raised the arsenic level in a receiving stream above recommended water-quality standards. In 1975, the United States electric utility industry produced about 50 million tons of solid waste that was rich in trace elements. A recent assessment projected an increase to 130 million tons of solid waste per year by 1980. This source of trace elements may become increasingly important in future lake pollution.

Currently, the smaller fly ash particles and the vapors that exit the stacks are the major source of power plant derived trace elements to the Great Lakes. They pollute the atmosphere downwind from the power plants. Subsequent fallout, both wet and dry, deposits the trace elements on the land and water surfaces of the Great Lakes basin.

Usually, soil and vegetation effectively retain trace elements on the land. But in areas where the deposition is accompanied by acidic rainfall due to air pollutants, such as oxides of sulfur and nitrogen, the acid reduces the soil's capacity to retain the trace elements, which run off into local waterways. This can result in severe water pollution. For example, in some Adirondacks lakes in New York, acidic rainfall has introduced sufficient quantities of aluminum to cause the extermination of brook trout in 90 percent of the affected lakes. Although certain areas along the northern margin of the Great Lakes basin may also become affected in this way, most of the soil and water in the basin has a high acid-neutralizing capacity and similar effects are unlikely in the Great Lakes as a whole.

Direct deposition on the surface of the lakes probably provides the major input mechanism for trace elements in the lakes. Most of the heavy industry and

Power plants as far inland as this one in Lansing, Michigan, spread trace elements that may end up in the lakes.

©Robert P. Carr



about 60 percent of the basin's coal-fired generating capacity is located along the southern margin of the lakes, and the prevailing southwesterly wind transports stack emissions from these sources out over the lakes. Most of these emissions will fall out within 35 miles of the source. The zones of maximum deposition are probably the lake surfaces northeast of such large, industrial cities as Chicago, Gary, and Cleveland.

Furthermore, atmospheric fallout is greater over water than over land because air turbulence is most intense when the water temperature is higher than the overlying air temperature. This situation occurs over the Great Lakes throughout most of the year, particularly during the fall, winter, and early spring. Greater demand for electricity during this cooler period of the year requires increased fuel combustion. Consequently, stack emissions increase during cooler months when atmospheric conditions are conducive to trace element deposition.

While there have been no direct measurements of trace element fallout over all the Great Lakes, two separate Lake Michigan investigations concluded that the atmosphere contributes a large fraction of the annual load of certain trace elements compared with natural inputs from tributary streams.

This should lead to higher concentrations of trace elements in the waters of the Great Lakes ecosystem. But generally speaking, the concentrations in the Great Lakes do not reflect the increased inputs, and most of the highly toxic trace elements are present at less than ten parts per billion. These levels do not exceed estimates of the average concentration in surface waters of the United States. Apparently, water chemistry, biological activity, and sedimentation interact to transfer trace elements from the water to the sediment. Recent measurements at Argonne National Laboratory revealed that the upper sediment layers in Lake Michigan contained two to four times higher concentrations of such trace elements as zinc and lead compared with sediment deposited about one hundred years ago. Similar trends have been observed in other lakes. The enriched elements in recent sediments are common in emissions from fossil-fuel combustion.

A few cases of above normal trace element levels in Great Lakes' biota have been reported, including elevated levels of cadmium, chromium, copper, and arsenic in certain fish species from Lakes Michigan and Huron. In another instance, apparently higher selenium levels were found in zooplankton from Lake Michigan. The area of highest concentration appeared immediately downwind from the Chicago–Gary metropolitan area. Fortunately, instances of toxic trace element accumulation in commercially important fish species from the lakes have been rare.

Recently, the rates of deposition of some trace elements in Great Lakes' sediment appear to be declining. This suggests that input rates are also declining and that efforts to comply with the Clean Air Act (1963) and its amendments are reducing the emission rates. However, this apparent decline may be offset by substantial increases in the basin's fossil-fired electric generating capacity in the near future. The future demands for electricity in the basin may require increasing the total generating capacity, from the present level of 62 billion watts to about 400 billion watts by the year 2020. Coal will play a significant role in meeting this demand. A recent assessment of increased coal use in the Midwest indicates at least a doubling of coal-fired generating capacity in the basin by 2020.

In anticipation of this trend, the electric utility companies in the basin are investing substantially in coal mining and transportation and acquiring ten- to thirty-year contracts for delivery of large quantities of coal. For example, Detroit Edison Company is currently constructing a large coal-handling terminal near Duluth, Minnesota, to transfer coal shipped by unit train from the Plains states to large ships for transport

A satellite photograph, below, shows smoke plumes from industries at the southern end of Lake Michigan drifting northeastward for more than one hundred miles. Right, soon after this photograph was taken in 1966, these blast furnaces of the Great Lakes Steel Division of the National Steel Corporation were leveled and replaced with furnaces meeting new air pollution requirements.

LANDSAT # 112416050, NASA

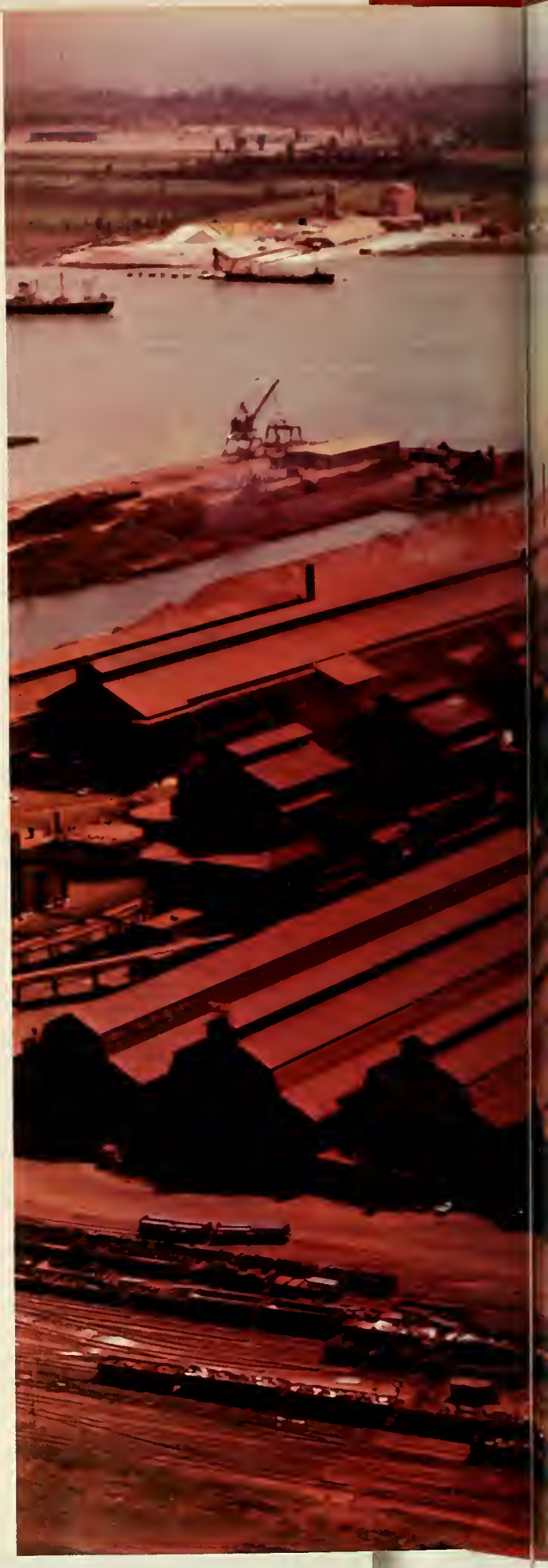


to new power plants in the Detroit region. Coal shipments on the Great Lakes are expected to double tonnage by the year 2000. A large coal-fired power plant is being planned southwest of Chicago. Coal for this plant will be barged on the Mississippi and Illinois rivers. Recent advances in barging efficiency and a lengthening of the barging season by improved ice-breaking techniques will expedite the flow of coal to the region.

The expected growth of coal-fired generating capacity in the basin may be constrained through enforcement of the 1977 amendments to the Clean Air Act. These set more stringent limits on emission of particulate materials and oxides of sulfur and nitrogen and establish zones that are to be protected against significant deterioration in air quality. If stack gas cleaning technologies cannot achieve compliance with the regulations, then alternative power-generation methods may be developed. In areas where air quality is poor, restrictions may be imposed on siting of new plants.

Improved controls may reduce each plant's particulate emissions by half, but if the total generating capacity is doubled, there will be no reduction in the basin's total emissions. Furthermore, the present regulations do not specifically limit the quantity of highly toxic trace elements adsorbed on the particulates nor do they limit the emission of trace element vapors. Increased coal combustion in the future could cause increases in the emission of such elements as mercury, selenium, chlorine, and bromine.

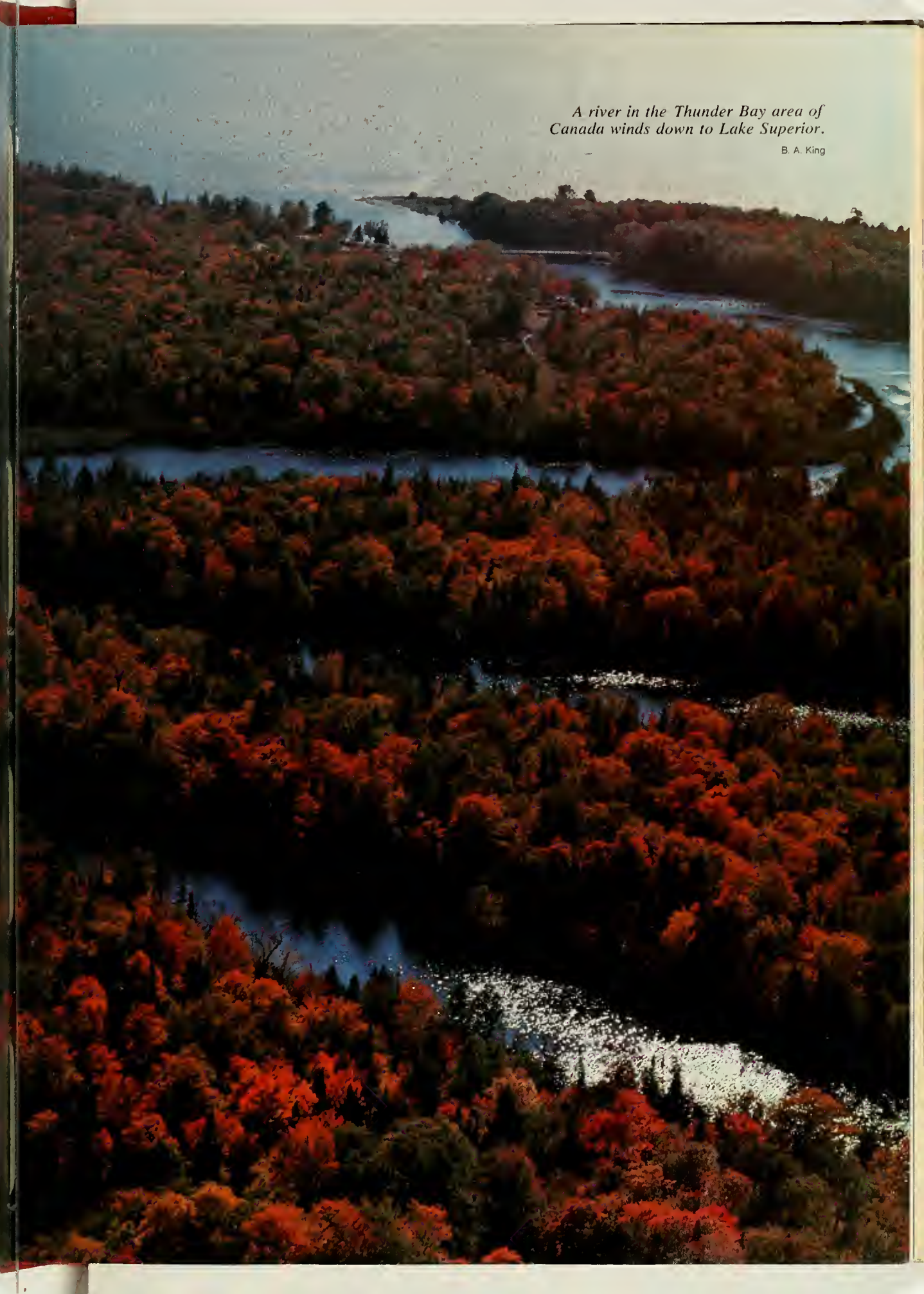
Further pollution by atmospheric trace elements probably will occur in the Great Lakes. While the impact on water quality may be minimal, the biota and sediment should be routinely monitored in the future to detect any changes in community structure related to trace element pollution. □



Charles B. Rotkin; PFI







A river in the Thunder Bay area of Canada winds down to Lake Superior.

B. A. King

Legacy of a Thirsty Society

Water intakes and cooling systems kill billions of plants and fish daily

by Steven A. Spigarelli

The demand for Great Lakes water is enormous and growing—and increasingly destructive of aquatic life. Some thermal electric power plants along the lake shores generate up to 2,200 megawatts of electricity and use inshore water at a rate as high as 2.6 billion gallons per day for condenser cooling. The single largest municipal water intake at Chicago withdraws approximately 900 million gallons per day.

The Great Lakes Basin Commission projects that as the human population of the region doubles between 1970 and 2020, the demand for Great Lakes water will increase tenfold (from 12 to more than 100 billion gallons per day). Today, up to 0.1 percent of the inshore waters are used every day for cooling purposes. By 2000, that daily figure probably will exceed 1 percent in Lake Michigan and 3 percent in Lake Ontario.

Every day, billions of small animals and plants and thousands of larger fish are killed or injured by intakes and cooling systems. During peak reproductive periods, billions of juvenile fish and millions of adult fish are killed daily. An electric utility study has estimated the numbers of fish eggs and larvae entrained at some power plants on Lake Michigan at greater than 5 billion alewife, 115 million smelt, and 1 million yellow perch. Extrapolation of these figures to all power plant and municipal water intakes provides estimates of egg and larval mortalities on the order of 15 billion alewife, 600 million smelt, and 1.5 million yellow perch.

The alewife, an exotic immigrant from the Atlantic Ocean, has become one of the most important fish in Lake Michigan. It has undergone huge population fluctuations in the past few decades. In the summer of 1965, millions of these small, shadlike fish died during their inshore spawning migrations, leaving massive piles rotting on the shores. Dead alewives clogged municipal and industrial water intakes, and large power plant generators burned out or were shut down because of reduced intake flows. Mortality was even greater in 1966 and 1967 when one-third to one-half of the total alewife population died off.

Despite the extreme fluctuations in its population, the alewife continues to be the most abundant fish in Lake Michigan. As the primary forage fish for salmon and trout, which are stocked annually, the alewife is the key to successful management of exotic salmonid stocks.

Recent studies by the Great Lakes Fishery Laboratory indicate that the standing crop biomass (total annual weight) of alewife remained relatively stable in Lake Michigan from 1970 until recently. But scientists are now concerned about new pressures on the alewife population from increasing stocks of salmonids, as well as by increased mortalities at water intakes. Studies at Argonne National Laboratory estimate that, at a minimum, about 37 percent of the total alewife biomass in Lake Michigan dies annually owing to three of the many stresses related to man's activities. This estimate includes 33 percent due to predation by stocked salmonid fishes, 3.5 percent in the commercial harvest, and 0.3 percent due to impingement of large alewives on intake screens. Approximately 42 million alewives, totaling 2.7 million pounds, were killed on Lake Michigan intake screens in 1975. This figure may be relatively small, but we do not know what levels of mortality constitute a threat to various species.

Several other Lake Michigan fish populations may be affected by water intakes, the most likely being the rainbow smelt and the yellow perch. Populations of both species have fluctuated greatly over the past few decades, probably as a result of intense fishing and the effects of the alewife fluctuations. A minimum of 55 percent of the standing crop biomass of smelt dies annually in Lake Michigan—42 percent by predation, 4 percent by commercial fishing, 9 percent by sport fishing, and 0.3 percent by impingement on intake screens. Yellow perch are not very abundant in Lake Michigan except in eutrophic areas such as Green Bay. About 2 million pounds of yellow perch are caught annually by commercial and sport fishermen, and of that amount, about 13,000 pounds are killed through impingement at water intakes.

The losses of adult and juvenile fishes at water intakes vary in the other Great Lakes. In Lake Ontario, alewife, smelt, sculpin, and white perch are the most common fishes affected by intakes, with impingement kills of adult fish as high as 5 million per year at large power plants. We have no estimates of lakewide mortalities of adult or juvenile fishes. The instability of Lake Ontario's fish populations and the projected increases in the lake's water use are of great concern to ecologists.

Lakes Huron and Superior both have low human-population densities and low levels of industrialization in their watersheds; thus, they have few water intakes. Major changes in native fish communities have apparently been due to invasion by exotic species, overfishing, and natural habitat alterations. By the year 2000, less than 0.5 percent of the inshore waters of these lakes will be used by power plants.

Lake Erie, because of its shallowness, has always been atypical and has experienced more rapid changes than the other Great Lakes. Recent studies at power plants on Lake Erie show high kill rates of yellow perch, gizzard shad, white bass, and alewife. An

Part of the 3,400-megawatt Bruce Nuclear Power Development Complex, which covers almost five miles of shoreline on the Canadian side of Lake Huron, the Douglas Point Nuclear Power Station was Canada's first full-scale nuclear electric generating station. The entire complex uses 4 billion gallons of water daily for cooling.

Malak of Ottawa



Metal housings cover traveling intake screens at the Douglas Point Station. The screens continually remove fish from the cooling water, killing them in the process.



David Jude

EPA-sponsored study has estimated that up to 10 million yellow perch larvae were destroyed yearly by one large plant in the western basin of Lake Erie.

Water intakes damage aquatic organisms in several ways. Water and its entrained organisms enter intake structures at velocities that vary from less than 0.5 to more than 5 feet per second, depending on the intake design. Velocity is a critical factor since free-swimming fish have size-related swim speeds and escape potentials; thus, at faster flows, higher numbers and larger organisms are overcome and trapped by intakes. At most intakes, water is filtered through a wire screen with ⅜-inch openings that keep debris from entering the pumping system. Large adult fish are impinged on the screen, collected, and hauled to disposal sites.

Smaller organisms, such as plankton and juvenile fish, pass through the screen to secondary filters in a municipal intake or to the circulating water system and condenser tubes in power plants. Circulating water pumps create several stresses on organisms—pressure changes, cavitation, and shear forces—while impeller blades cause direct mechanical damage. In the one-inch condenser tubes, water temperature rises as much as twenty degrees in a few minutes and the water often becomes supersaturated with atmospheric gases. Both rapid temperature changes and supersaturation of gases can kill organisms. In addition, biocidal chemicals, such as chlorine compounds, are injected into the intake water to control bacterial slimes. These chemicals are toxic to organisms entrained in the water.

Most Great Lakes power plants pass water through a cooling system only one time, then discharge the heated water directly into the lake, where it cools. A few power plants use closed-cycle cooling devices, such as cooling towers, which recirculate the water. These devices can substantially reduce the volume of intake water and the numbers of entrained organisms. Since most water intakes on the Great Lakes have no provision for fish to bypass the screens and return to the lake, all fish that enter intakes are impinged on the screens and killed. Small organisms that pass through intake screens coincidentally with biocide treatment are also killed. Those that pass through the circulating system and condensers have a variable chance of survival, but scientists usually assume 100 percent mortality. All aquatic organisms entering municipal water intakes are killed since the entire flow is filtered and treated with biocides.

Power plant intake effects can be mitigated in several ways. One is to reduce the rate of water flow at intakes. At some modern power plants, the large volumes of water used to cool condensers were considered necessary to meet water quality standards for temperature at discharge. But extensive studies have indicated that high discharge temperatures have little impact on populations of Great Lakes organisms. If intake flow rates are decreased where possible, discharge temperatures will increase, but the numbers of organisms affected will decrease. A reasonable way to mitigate total power plant effects on aquatic organisms might be to balance the effects of discharge temperature against those of flow.

Cooling towers, ponds, and canals can reduce cooling water requirements by allowing recirculation of cooled water. But these devices have some drawbacks: they are expensive to build, their environmental effects are not well understood, and there is limited land available for the necessary facilities. In addition, cost-benefit analyses of cooling towers, the most efficient of these systems, continue to show alternative methods of cooling to be less favorable than the once-through process (on the Great Lakes). Alternatives will compare more favorably if new impact assessment methods project unacceptable (from a social or biological standpoint) losses of biota or changes in ecosystem function due to once-through cooling.

Another way to reduce intake effects is to vary intake flows to take advantage of periods of low abundance in affected organisms. This approach requires detailed knowledge of the distribution and life cycles of biota and extensive coordination of production schedules within the power generation network.

The problem of fish being impinged on intake screens could be reduced through modifications to existing intakes and better planning of new facilities. Among the schemes that have been tested—with little success—are fish repellents and behavioral barriers such as electrical and air-bubble screens, and underwater sounds and lights. Fish protection devices (bypasses, louver systems, and horizontal traveling screens) seem to hold promise for returning fish to the lake before they are impinged. A third method of reducing impingement and entrainment, fine-meshed screens, will soon be tested at Great Lakes sites.

Finally, proper siting of water intakes, based on detailed knowledge of the distribution of organisms and of the performance of different intake designs is a crucial first step in alleviating the harmful effects of water intakes at new power plants. Although the present levels of fish and plankton kills through impingement and entrainment may not be ecologically significant, projections of rapid increases in water use indicate the need for new ways to mitigate future ecological effects of cooling systems on the Great Lakes. □

The Salmon May Make It

Hatchery-produced fingerlings thrive and grow, but will they ever spawn naturally?

by Stanford H. Smith

The catastrophic changes in Great Lakes fish stocks during the past century illustrate the fragility of fish communities in oligotrophic lakes (cool, clear lakes rich in dissolved oxygen) affected by human population growth and technology. The earliest descriptions of the Great Lakes reported major spawning runs of salmonines (trout and salmon) and other kinds of fish in estuaries and tributaries. But since the mid-nineteenth century, one of the two most abundant salmonines, the lake trout, was significantly reduced or reached near-extinction in various lakes; and the other, the Atlantic salmon, became extinct in Lake Ontario by 1890.

The Atlantic salmon was once the dominant piscivore in Lake Ontario, but was not found in the other lakes because of the upstream barrier of Niagara Falls. The lake trout was originally abundant in Lake Ontario and was also the climax predator in fish communities of the other deepwater lakes—Superior, Michigan, and Huron.

Individually and collectively, four factors disrupted the formerly stable and productive fish communities in the lakes: intensive exploitation by fishermen; extreme modification of drainage basins and tributaries, particularly through deforestation; establishment of marine species, primarily the alewife and the sea lamprey, by invasion or introduction; and cultural eutrophication, or progressive physical and chemical modification of lake environments.

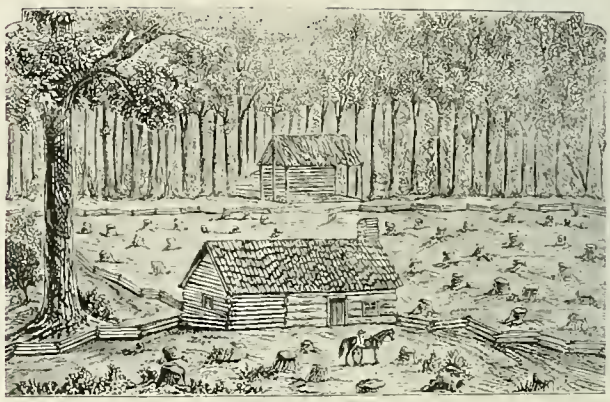
The effects of drainage modification that were unfavorable for Atlantic salmon permitted establishment of the sea lamprey, which in turn was a major factor in the severe reduction of lake trout. The natural reproduction of lake trout and other salmonines declined drastically in Lake Ontario in recent decades, a period of rapid cultural eutrophication.

The term "cultural eutrophication" includes physical and chemical changes, natural and unnatural, which occur at much greater than natural rates and result in increased plant nutrients and decreased oxygen. Both processes contribute to a deterioration of water quality in the sense that they are detrimental to the presence and productivity of useful aquatic life, including desirable fish, or favor destructive or obnoxious aquatic life. The ways in which cultural eutrophication causes the decline or disappearance of deepwater fish are poorly understood or unknown. Species of fish have, however, declined or disappeared in the same sequence in different lakes or regions of lakes during periods of accelerated changes in water quality or temperature—in both the presence and absence of commercial fisheries and other inimical factors.

Considering the geographical location of the Great Lakes, such declines might be expected. The southernmost of the large oligotrophic lakes of the Northern Hemisphere, the Great Lakes are at or near the southern end of the range of many species typical of a cold-water environment or of large oligotrophic lakes—Atlantic salmon, lake trout, lake whitefish, lake herring, deepwater cisco, and deepwater sculpin. It seems natural that such species would become rare or disappear in once oligotrophic bodies of water that now have eutrophic chemical and morphometric characteristics (Lakes Erie and Saint Clair, and Green and Saginaw bays) or that remain essentially oligomorphic but have eutrophic water quality (Lake Ontario). Significantly, the families or species with a more northerly range or those associated with colder water are among the first to decline or disappear. The Atlantic salmon, until the late nineteenth century the dominant species in Lake Ontario, was the first of these.

The Atlantic salmon was fished intensively in Lake Ontario because it was easily taken during spawning migrations. Yet it was used less wastefully than other fish because of its excellent quality as food and its high economic value. The salmon were a primary source of protein for the early settlements and military outposts, and the value of salmon runs sometimes determined the value of land. When the salmon declined about 1850, the fishermen, thinking the lake had been fished out, moved to other lakes or turned to other professions, leaving behind deserted lakefront fishing communities. But the fish stocks failed to recover despite strong protection and persistent introductions of hatchery fish.

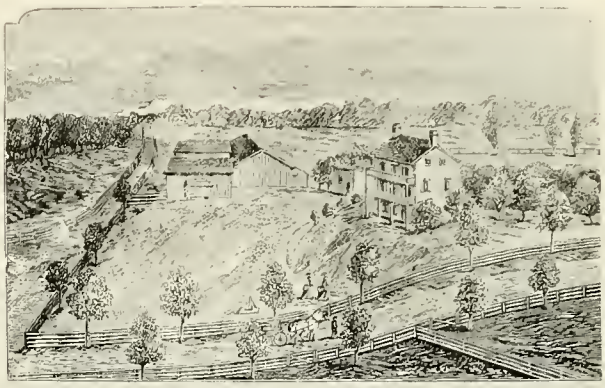
As the Atlantic salmon disappeared, so did the forests. The two events probably were closely related. The virgin forests were once described as "so thick-set with trees and so dense . . . that a savage might skulk



THE HOUSE BUILT 1836

Two nineteenth-century engravings show how early settlements cut into the forests.

From *The Bark Covered House*, the memoirs of William Nowlin, 1876
Courtesy of Michigan State Library



from the Hudson to Lake Erie without exposing himself to the glare of the sun." But in the early and mid-nineteenth century, the forests were cut to clear land for agriculture and to provide lumber, fuel, tanners' bark, charcoal, and potash for industry. The cutting started in the eastern area, and in 1897, one observer described the western New York drainage area of Lake Ontario as "almost totally deforested." The drainage of swamps for farmland and the construction of dams for water-powered mills, together with deforestation, turned the "living streams" and rivers, which had flowed cold and clear throughout the year, into streams with reduced summer flow that was sometimes warm, sluggish, or intermittent. Many were severely polluted by wastes from the mills. Pollution and reduced flows adversely affected most streams where Atlantic salmon spawned, but runs of salmon also disappeared in some streams unaffected by these factors. One factor that affected every stream in the drainage was the increase in stream temperature due to the loss of the forest cover.

Studies have demonstrated the importance of water temperature in successful reproduction of salmon. Between 1944 and 1947, the Province of Ontario conducted intensive research on Atlantic salmon planted in Duffin Creek, a tributary of Lake Ontario that had been a good salmon stream in the mid-nineteenth century, but where years of introductions had failed to reestablish a spawning run. This study showed that two major causes of mortality were inadequate shelter to protect young salmon from predation and high water temperatures in the lower portions of the stream. "Those tributary streams in which lethal summer temperatures destroyed the salmon populations . . . lacked any appreciable amount of shade, whereas those streams with suitable temperatures had a larger proportion of shaded sections." Conditions other than temperature and shelter for juvenile salmon were considered "of minor or no importance in salmon survival."

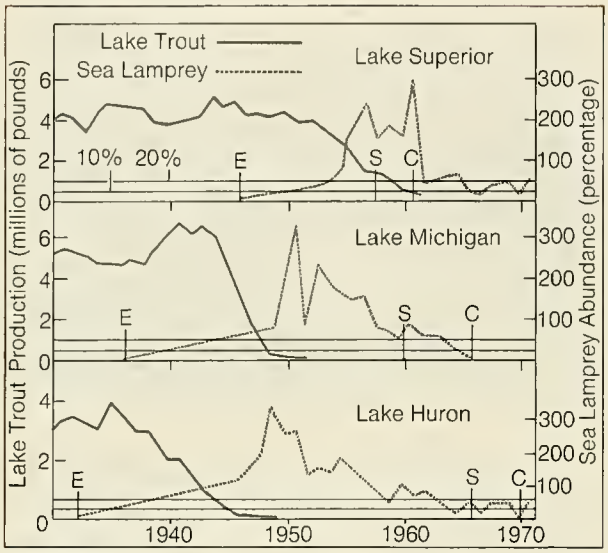
A 1960s study of salmonid streams in forested and deforested areas of Oregon—which is at the same latitude as the Lake Ontario basin and receives comparable solar radiation—showed that before the forest was cut, stream temperatures for July, August, and September averaged 51.8°F, with a diurnal fluctuation of from 47.1° to 56.6°. Following forest removal, the average temperature was 59.1°, with a diurnal fluctuation of from 48.5° to 75°. Juvenile Atlantic salmon, which usually spend two years in a stream following hatching, have maximum food conversion at about 53° and have been observed thriving in streams with temperatures of about 55°. These temperatures are within the range for streams in forested areas, but they are considerably below the warmer temperatures of those streams after forest removal. Thus, unfavorable stream temperatures, primarily as a result of forest removal, may have been a controlling factor leading to the decline and eventual extinction of Atlantic salmon in Lake Ontario and, later, may have prevented reestablishment of the fish in the lake's drainage basin.

The loss of the Atlantic salmon and the related environmental modifications were apparently the triggering mechanisms for a sequence of changes in fish stocks that started in Lake Ontario and spread throughout the Great Lakes. The most significant of these events was the establishment in the late nineteenth century of major populations of alewives and sea lampreys—marine species that spawn in streams and spend their adult life in the ocean, but which can complete their life cycle in the freshwater of the Great Lakes.

The alewife, the first marine invader to become conspicuously established in Lake Ontario, was described as being abundant when it was first observed in 1873. Its most probable route from the Atlantic was through the Hudson River and the Erie Canal. The alewife might have reached Lake Ontario earlier via the Saint Lawrence River, but experience in the upper Great Lakes has shown that the alewife probably cannot become established or thrive in the presence of an abundant large piscivore such as the Atlantic salmon. Thus the Atlantic salmon may have been a deterrent to the entrance of the alewife via the Saint Lawrence River.

Alewives apparently negotiated the Erie Canal's locks and spillways with difficulty since not until 1868 (forty-three years after the canal's opening) was their presence noticed in the Oswego River drainage below the Finger Lakes. Even before becoming established in the Finger Lakes, some alewives were undoubtedly

Commercial production of lake trout and sea lamprey abundance in Lakes Superior, Michigan, and Huron: E is the date of lamprey establishment; S is the date of the start of lamprey control; and C is the date of the completion of lamprey control. Lines show 10 and 20 percent of the average of the three peak years of lamprey abundance for each lake.



Stanford H. Smith

moving downstream in the Oswego River into Lake Ontario, where they remained unnoticed until 1873. At the time of this movement, Atlantic salmon were decreasing rapidly.

Experience in the other Great Lakes has shown that in the absence of a large population of piscivores, alewives that become established in a large deepwater lake can increase rapidly and become the most abundant species in less than twenty years. When the alewife overpopulates a lake, major changes occur in the growth, condition, and age structure of its population. At high population density, the alewife suffers mass mortalities from cumulative stresses.

Food competition appears to be the mechanism by which the alewife dominates other species. The alewife's ability to reduce or eliminate all large plankton from a lake may deprive other, larger species of the food necessary for their survival. Among the fish eventually affected by the alewife's spread west, from Lake Ontario through the upper lakes, were the lake herring and emerald shiner (shallow-water planktivores), the rainbow smelt and yellow perch (facultative planktivore-piscivores), and the deepwater cisco and deepwater sculpin (deepwater planktivores). The deepwater fish were prey for the lake trout.

The most conspicuous change in fish communities of the Great Lakes came with the invasion and establishment of the sea lamprey, which followed the domination of Lake Ontario by the alewife. The parasitic sea lamprey feeds primarily on large fish, such as the lake trout, that live in its preferred deepwater environment.

The causes of the sea lamprey's incursion from the Atlantic are not yet fully understood. Although a sea lamprey was identified in Lake Ontario as early as 1835, a population of lampreys was not established in the lake until the 1880s. Evidence strongly suggests that the sea lamprey came into the Lake Ontario drainage basin via the Erie Canal from the Mohawk–Hudson River drainage, which enters the Atlantic in a region where the species, historically, was very abundant. The sea lamprey, like the alewife, was first reported in the Finger Lakes, where it was abundant by 1870. The lampreys could have progressed upstream through the river and canal system either by swimming or by attaching themselves to the hulls and rudders of boats. The question is why it took so long for this to take place, since the Erie Canal was opened in 1825.

The sea lamprey's inability to sustain itself in the Lake Ontario drainage basin until the mid-nineteenth century, when it became populous in Cayuga Lake, may be related to the decline of the Atlantic salmon at about the same time. The increased water temperature in Lake Ontario's tributaries caused unfavorable conditions for the reproduction of Atlantic salmon, but it could have created favorable conditions for the reproduction of the sea lamprey. To reproduce successfully, Atlantic salmon require cold stream conditions; warmer stream conditions are required to stimulate sea lamprey spawning migrations and to produce conditions that result in successful development of eggs.

We know through recent experience with sea lampreys that there is a critical relationship between temperature and reproductive cycle. Sea lampreys usually enter spawning streams warmer than 40°F; their spawning migration is stimulated by temperatures between 50° and 65°, and spawning itself is stimulated by temperatures between 52° and 75°. Peak spawning activity usually occurs in water with a temperature of about 60°, almost 5° above the ideal water temperature for Atlantic salmon. Laboratory studies using constant temperatures show that nearly all successful hatching of sea lampreys occurs in the narrow temperature range between 60° to 70°, with high survival of eggs to hatching limited to an interval of two or three degrees in the middle of this range. Under the fluctuating temperatures of natural stream conditions, hatching success ranges from 0.4 to 7.8 percent, which is considerably below the survival rate of 78 percent that can be obtained in laboratory conditions.

Studies of lakes in the Oswego River drainage basin confirm that sea lamprey reproduction is correlated with water temperature. Lakes with thriving lamprey populations have streams with temperatures in the 60°

Frederick Norman's painting Log Jam *(ca. 1855) depicts lumbermen at work along the partly denuded banks of Michigan's White River.*



White Lake office, Muskegon Bank and Trust Company

The sea lamprey's jawless, suckerlike mouth has a horny-toothed, tonguelike structure, which rasps into its prey's flesh.



Manford Storch, Sea Lamprey Control Center



to 70° range. Lakes without lampreys have tributaries whose temperatures are well below that range during the sea lamprey reproductive period in the spring and early summer. In addition, evidence indicates that if a lamprey does not spawn in one stream because the water is too cold, it will not spawn in another stream that it might move to, even if the water in the new stream is of the right temperature. So there is much evidence to support the assumption that deforestation and the resultant change in stream conditions were the dominant factors facilitating the invasion and establishment of the sea lamprey and, concurrently, contributing to the extinction of the Atlantic salmon and the proliferation of the alewife.

Once established in Lake Ontario, the sea lamprey and the alewife were able to reach the upper Great Lakes by moving through the Welland Canal, which bypasses Niagara Falls between Lakes Ontario and Erie. In the upper Great Lakes the lamprey caused a decline of lake trout as drastic as that of the Atlantic salmon in Lake Ontario. Because the lamprey did not become established in Lake Ontario until after the fisheries had declined and fishermen had moved to other lakes, the seriousness of its threat did not cause alarm. Research needed by fishery managers to stem or counteract effects of the sea lamprey was not initiated until 1946—more than eighty years after the invasion from the Atlantic and more than fifty years after problems caused by the lamprey on the Great Lakes had been recognized in the Finger Lakes and Lake Ontario.

That research led to the development of a selective toxicant that would kill young lampreys in the spawning streams but, when carefully applied, would have little or no adverse effect on other species. Between 1958 and 1972, all known lamprey-producing tributaries of Lakes Superior, Michigan, Huron, and Ontario were

Fastened to a lake trout, a parasitic sea lamprey sucks its prey's blood and other body fluids for nourishment.



Tom Stack; Tom Stack and Associates



An alewife die-off on Lake Michigan, near Chicago

treated with the larvicide TFM (3-trifluoromethyl-4-nitrophenol).

The adult lamprey population was reduced to 20 percent of peak abundance after all streams of Lake Superior had been treated once with TFM, and to less than 10 percent after the streams had been treated twice. By the late 1960s, the lake trout had attained or surpassed prelamprey abundance in areas of intensive stocking. Conditions are still in a state of flux, but the sea lamprey population, which persists under present control technology, continues to cause substantial lake trout mortality. Indications are that even with sea lamprey control, the lake trout population would collapse if lake trout stocking were ended.

Sea lamprey control and lake stocking have, in combination, made conditions more favorable for the sea lamprey by doing for it what many humans would like to have done for themselves. These programs have created a controlled, uncrowded population of lampreys with plenty of freedom and an abundance of food for all. Under control, the lampreys have all the favorable conditions that fostered their initial population explosion, and in addition, they have recovered from the stresses that accompanied peak population density. Compared with the time of maximum population density of lampreys in Lake Superior, the less dense populations of lamprey ammocoetes (larvae) in streams are growing faster and are younger and larger when they transform into adults. The adult lampreys are also growing more rapidly and maturing at a larger size. The larger adult females produce more eggs, and the proportion of females in spawning runs has reached about 80 percent, compared with about 30 percent at peak abundance. These conditions suggest that survival of larval and adult sea lampreys has improved and that reproductive capability has increased. Control has been intensified in recent years to counter the more favorable conditions for sea lampreys, and to keep their "controlled" level low enough to maintain favorable conditions for stocking and maintaining large populations of lake trout and other salmonines.

In recent decades, cultural eutrophication has become an added factor that has limited natural populations of lake trout, which have become less abundant or have disappeared in such greatly enriched areas as the southern portions of Green and Saginaw bays and all of Lakes Erie and Ontario. Apparently, natural lake trout reproduction ended in Lake Ontario about 1950 and naturally produced lake trout were virtually extinct by 1960. This disappearance could not be attributed to the sea lamprey, which had been well established for the preceding eighty years. Lake trout persisted and even became quite abundant during the period between 1910 and 1930, when lampreys were common. Also, commercial and recreational fishing were greatly reduced or absent, particularly in the deeper areas where trout lived. Other deepwater species, such as the deepwater cisco, lake herring, and deepwater sculpin, also became extinct or nearly so after lake trout declined.

These species are characteristically found in oligotrophic lakes, but apparently Lake Ontario, as well as other lakes where they disappeared, became so enriched through cultural eutrophication that reproduction was inhibited. The enriched lake environment, however, still seems to be satisfactory for adult lake trout and other salmonines, which can be raised in hatcheries and released as juveniles.

In both highly enriched and little enriched areas, the introduction of hatchery-reared Pacific salmon and lake trout has been very successful following sea lamprey control. Recent introductions of Atlantic salmon, however, have not been similarly successful, indicating that some factors of the lake environment may be inimical for their adult life in the Great Lakes today. In the absence of adequate natural reproduction, artificial propagation apparently makes it possible to maintain thriving populations of lake trout and some other species of salmonines, such as coho and chinook salmon, rainbow-steelhead trout, and brook and brown trout, under present lake conditions, provided sea lamprey abundance is simultaneously controlled.

The only salmonine that seems to be thriving through natural reproduction is the small pink salmon, which was unintentionally introduced into Lake Superior in 1956. The pink salmon has now established substantial spawning runs in all regions of Lake Superior and is spreading into Lakes Michigan and Huron. It is still uncertain if this fish will be able to pass through the rich, shallow waters of Lake Erie, which is not ideal salmonine environment, and to reproduce and thrive in the enriched waters of Lake Ontario.

Apparently, an abundance of salmonines can be maintained in the presence of the sea lamprey if advanced cultural eutrophication does not cause water quality to become less favorable. This represents only partial restoration of the fishery productivity of the Great Lakes, however, because species such as the deepwater cisco, lake herring, and deepwater sculpin, which once constituted some 80 to 90 percent of the pounds of fish in the Great Lakes, cannot be mass-produced by known hatchery techniques and will continue to remain at low abundance or absent in many areas until the restoration of water quality that will permit them to reproduce and thrive. □

Thomas Mulligan, Miller Services



"You'll Always Get Home"

Until recently, families with inherited knowledge of fish behavior dominated Great Lakes fishing

by Russell McKee

In one way, the commercial fisheries on the Great Lakes have changed very little over the past century. The tonnages of fish taken from the lakes by commercial fishermen one hundred years ago, fifty years ago, and today are almost identical, with an average catch over the century of 113 million pounds per year. In only twelve of those years has the annual average fallen below 100 million pounds. That remarkably stable record was brought about by tough, knowledgeable, often fractious fishermen who, if not among our earliest naturalists, have long been an important natural element of the Great Lakes ecosystem. Although their numbers are dwindling, their importance continues.

The record does not show how many were actively fishing a century ago, but by 1900 the total was estimated at about 6,000 fishermen on the United States side of the lakes. In 1917, the number peaked at 10,000, then began a slow but steady decline. It was never that high on the Canadian side and has declined there as well. Today the total stands at only about 2,000, divided almost equally between the United States and Canada.

Commercial fishermen of the Great Lakes today or, for that matter, of the past are difficult to typify. Yet they have common backgrounds and bonds that place them as a group among our most aware and well-informed users of the outdoors. This does not mean that they do not have blind spots or failings, that they have been completely virtuous in their use of the fishery or that they are necessarily better protectors of the environment than others. But they experience so much of the natural world in their daily work that they hold as common what most people today may never learn in a lifetime of outdoor search.

Present-day fishermen are, almost to a man, descendants of commercial fishermen whose fathers were also descendants of fishermen. In the years following the Civil War, cities rose in the Great Lakes region, built largely of pine and hardwoods cut from the vast forests of the area. The lakes were the highway for shipment of this lumber, and the shorelines were the natural sites for the cities then being built. Commercial fishermen thrived because the development of many small ports and several large cities around the lakes gave them both a base of operations and hungry markets to supply. In the upper lakes region, for example, where agriculture provided only thin subsistence, logging camps and lumber towns needed a daily source of protein, which commercial fishermen were able to supply. Iron and copper miners around the west end of Lake Superior also needed fish, as did the booming cities of Chicago, Milwaukee, Detroit, Cleveland, Buffalo, and Toronto.

By the turn of the century, the fishing industry had become well established as a group of small, family enterprises. Typical upper lakes ports might support half a dozen fishing families, and because these were mostly small towns (and remain so today), the fishermen of each community knew each other well. Thus, while they competed for fish on the lakes and for markets on shore, they also had to live together, which produced what might be described as an extended family held together by a mutually competitive spirit and daily use of a common marketplace and a common fishing ground. Consequently, once commercial fishing became established, it also became a very stable social institution. In this small town push and shove, nobody got rich, but fishing families thrived, outsiders were kept out, and gaining the respect of other fishermen was a goal worthy of a life's work.

A member of such a clan had to have a wide range of practical knowledge and skills. He had to be skilled in the construction, handling, management, and repair of boats. He had to know his lake intimately. He had to be a storekeeper, salesman, and market manager. And he had to be a weatherman. Fogs, blizzards, and ice storms sweep off the shores and across these lakes with blinding speed, and someone preoccupied with lifting nets or untangling lines can suddenly find himself locked in a small, white, very angry room. At that point the brainpan must call forth from memory a highly detailed chart of the entire area surrounding the boat, including islands, shoals, channels, and the nearest safe haven.

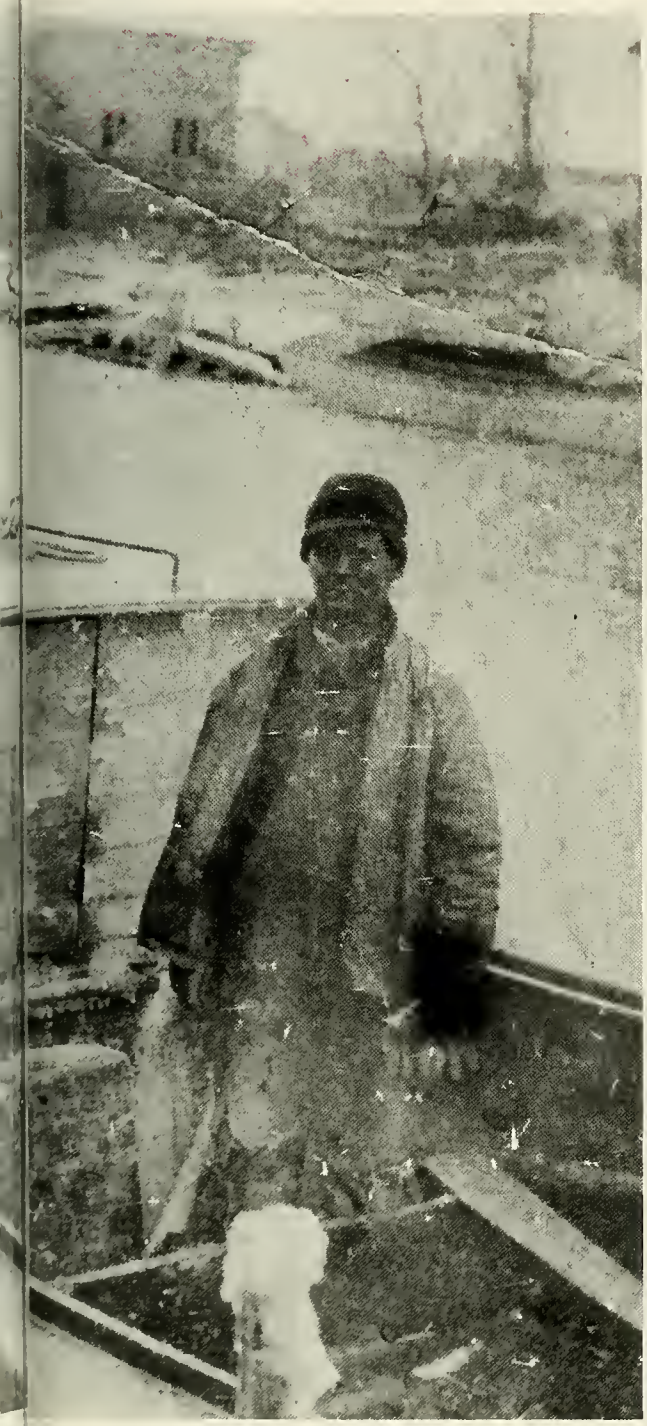
One fisherman from Saginaw Bay recalled a story about an old-timer, a one-armed fisherman named Harvey Dutcher, who took a gathering of local youngsters on his small, sail-powered fishing boat one Fourth of July and dropped them on an island a dozen miles out in the bay. They would have a picnic while he fished, and he would pick them up on his return. But in the afternoon a storm came up and fog blanketed the bay. Soon, worried parents gathered at the dock, where visibility was zero. The world around them was nothing but howling white walls. Darkness fell and anxiety rose. Toward nine that evening the wind dropped, but seas in that dishpan bay remained violent. Suddenly, near midnight, without sound or warning, Dutcher's little vessel, loaded with kids and tugged along by one small sail, eased out of the fog and snuggled up next to the pier. A collective sigh of relief rose from the parents, but Dutcher himself shrugged off his pinpoint landing as routine. "Jest listen to the shore sounds," he said, "and watch the water under you. Hell, that ain't much to do. You'll always get home."

A nineteenth-century lake trout catch
John Bardon, Northeast Minnesota Historical Center

Seven generations of the Dutcher family (Peter is second from the left in this 1920s picture) have fished Lake Huron, but now there are no sons to take over.



Courtesy of Mrs. Walter Jahr



Others haven't been so aware or, in many cases, so lucky. A single storm in 1913 swallowed seventy-one Great Lakes ships, including nine 500-footers. Nearly three hundred lives were lost in that storm. Dozens of ore boats and cargo vessels have been lost over the years, while countless small craft of the size used by commercial fishermen have simply disappeared. Most fishermen working today can tell of at least one relative taken by the lakes. They have all had boats smashed, nets swept away, docks and fish houses torn up or bowled over. Those who survive were born with—or developed—wits enough to ride these waters with a deep and abiding respect.

Above all else, the successful fisherman knows how the fish think, where they travel, where they lurk in schools, when they might be likely to rise from twenty fathoms to fifteen. That may not seem much of a difference, but it is enough to bankrupt a man if he doesn't know the answer.

"Somehow those old-timers can always tell where the fish are going to be," says Ken Loftus, a fisheries director for Ontario's provincial government. "It's often difficult for them to tell you how they know, but dammit they know. There are a lot of wise old dogs out there."

In short, like the medieval guildsman, the Great Lakes fisherman has secret knowledge. He holds a bounty of natural wisdom locked in his head, some passed on from his father, some drawn from even earlier generations. By contrast, anyone who ever came to this business with no background did so at a severe and dangerous disadvantage. Fish are a cash crop and fishermen must live on their daily income, so an outsider who does not know the territory or the fish could starve before he is well started in the business. All of which produces in the survivors a central vein of blunt practicality and an absolutely undentable core of personal independence.

This practicality shows up in the boats these men designed for their work. Virtually all these boats are different, yet most are much alike in their appearance. And nothing beats a 1930s Great Lakes gill net fish tug for ugliness. They look like 39-foot outhouses plunked down lopsided on 40-foot dishpans. They perch so high on the water you expect them to turn turtle at the first puff of wind. Their small, beady-eyed windows look out suspiciously on the lakes, as though glaring at ancient enemies. As a class, they have gathered more scales over the years than all the fish they seek. When painted, which is seldom, the color is inevitably a gray not found on any color chart; when repaired, which is often, the standard materials are pie tins and tar or tar paper and

roofing nails or window glass and plywood. And they are durable.

But looks are one thing and work is another. For use in commercial fishing, these tough little boats incorporate a full range of practical virtues. Although perched high on the water, they are amazingly stable craft. Sleet and snow cannot ice the nets stored inside. A five-ton following sea slapping that blunt stern simply means a faster passage home. The small windows and durable materials are inexpensive and long lasting. And no fisherman was ever expected to love his boat for its looks. What he designed and built was what he needed for his work, and it is a tribute to the canny ways of his forebears that the design of the twenties and thirties is still used in the few steel tugs now being built.

But the old guard of fishermen is thinning out, and few new recruits are coming into the business. Thirty-five years ago, Bob Lang started a wholesale operation at Hancock, Michigan, called Lake Superior Fisheries. I asked him how many fishermen in his area had learned the business from their fathers. "Every one of them," he said without hesitation.

"And how many have sons working now to take over those businesses?"

"Not one. Not a one. Zero. Back when I started here in 1943, there were five wholesalers and more than twenty fishermen working this end of Lake Superior. Everybody had sons in the business then. Today I'm the last wholesaler and we're down to ten fishermen. Most of them are getting on in years, and not one has a son working on the boats. Things don't look too good for the future, what with pesticides and mercury keeping fish off the market, and all the kids going off to college or taking good-paying jobs in the city. And government restrictions are cutting the daily hauls in favor of sport fishing. Maybe things will pick up, but it doesn't look too good right now."

Roy Jensen, at Escanaba on northern Lake Michigan, takes a more optimistic view. His grandfather Jensen and an uncle named Hansen came from Denmark in the 1890s and started a fish business at Escanaba. Roy's father entered the business soon after the turn of the century, and Roy himself began on the boats as a youngster in 1931. Then the company converted to wholesaling fish caught by other fishermen, and for a long time Hansen and Jensen was one of the major Great Lakes contributors to the Chicago, Detroit, and eastern United States markets. Last year, Roy and his wife, Feryne, closed the company and retired. There was no one to take it over, and restrictions on fishing were too severe to continue. But he feels that times will change and that the present decline in fishing activ-



Two commercial fishing boats wait out a 1977 snowstorm in Bayfield, Wisconsin. Their skippers fish for whitefish, herring, and lake trout.



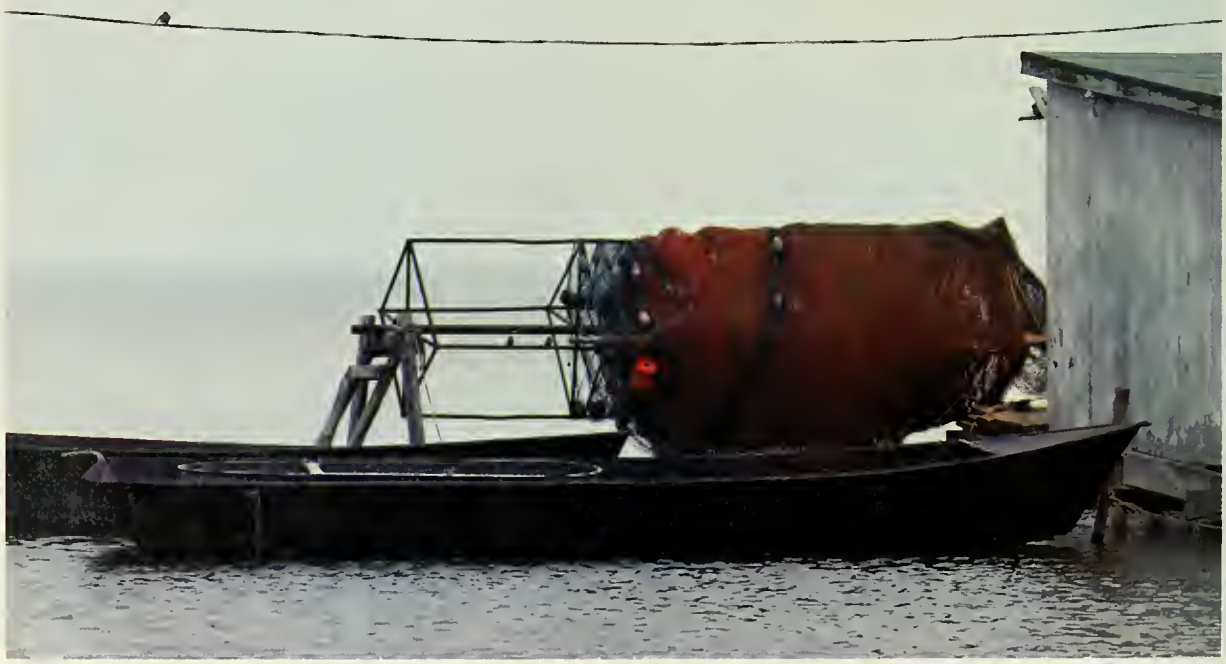
Richard Olsenius

ity means fish stocks are building steadily in the lakes. "There are some young fishermen coming into the business," he says. "If they can get started, they'll be able to make a good living. I think better days are coming."

Leonard Dutcher, at Point Detour on northern Lake Huron, is another fisherman with deep roots in the industry. He says he recently found a family tree that traces his Great Lakes ancestry back seven generations to the late eighteenth century. "They were all fishermen," he says, "every one of them. I've fished since I was sixteen years old, when my grandfather Peter Dutcher had the company. My dad, Clarence, eventually bought out my grandfather, and then I bought the company from my father in 1963."

Leonard, however, does not have a son to take over after he retires. "I'm out on the lake at least four days a week, and we're probably the oldest family setting trap nets on the entire Great Lakes system. I know my family may not continue with the business here, but I think things are going to pick up for others. The lakes need commercial fishermen. Sport fishermen can't take nearly enough fish to keep the harvest up where it should be. And we need those fish as a food source, so I think fishing's going to improve some time soon."

Maybe so. Maybe there will be a rebirth of fishing activity when the alphabet soup of chemical pollutants clears from these waters and research leads us to better harvesting methods. But even if that happens, the fishermen of the future are clearly going to be a far different breed from the 2,000 old-timers now spinning out their destinies on the lakes. The new wave of fishermen won't come from the old families because the old families are dying out or drifting off. They will find their hauls with electronic fish finders and will have no need to memorize every hump and hummock of the lake bottoms over which they travel. Radar will protect them from ore boats in the fog, and Loran will lead them electronically to safe harbors. Their boats will carry corporate names, and crews will be unionized. They'll work for weekly salaries and get computer-printed paychecks. Boards of directors will sit at polished mahogany tables and decide where and when and how much each boat will work and produce. There will be profits, of course, from start to finish, and hardly anyone will ever notice that there have also been some losses. Not important, just 2,000 names gone from lakes surrounded by millions of people. □



Nets drying on Lake Erie

B. A. King

The Computerized Ecosystem

The widely misunderstood tool of mathematical modeling helps ecologists answer many questions about the lakes

by Wayland R. Swain

Several years ago, a group of scientists associated with the Environmental Protection Agency prepared a mathematical model of Lake Erie. The model was designed to predict the extent of anoxia (oxygen deprivation) in the lake as a result of increased nutrient loads from sewage treatment plants, factories, the atmosphere, and farms. For a number of years, scientists had been concerned with the accelerated rate of eutrophication of Lake Erie brought about by the discharge of the wastes of human activity. Lake Erie had become so highly productive of undesirable nuisance algae and so depleted of oxygen in its lower layers that the popular press was moved to report that the lake was dying.

The modelers considered many agents and processes in their mathematical simulation of how the lake ecosystem worked. Through a complex series of equations, they were able to mimic in a computer the seasonal cycle of the lake.

Use of the model simulating Lake Erie's aging process suggested that the size of the area of anoxia appeared to be related directly to the extent of nutrient loading into the lake. But in 1975 the anoxic area was found to be markedly smaller than predicted by the model. To all appearances, the efforts of ecologists and environmentalists were having a major effect, even though the model suggested that the lake's improvement was so rapid and drastic as to be unbelievable. The press now began to herald the "rebirth" of Lake Erie, and some scientists grudgingly admitted that the lake apparently was improving, despite what the model had predicted.

As public awareness heightened, pressure for complete answers to the question of the vitality of Lake Erie grew. When Great Lakes modelers examined 1975 inputs, they discovered that nutrient loadings were similar to those of previous years and that, with a single exception, all important variables had remained significantly unchanged.

The single altered variable was temperature. Spring arrived much earlier in 1975 than it had in previous years and without the fresh winds that usually accompany its coming. As a result of the early rapid warming and minimal mixing, only a small portion of the lake's water made up the warmer surface layer that floats in the cold, deep water. The greatly increased fraction of deep water was freshly charged with oxygen after the recent spring overturn, in which the entire lake was mixed. Consequently, in 1975 a vastly increased amount of oxygen was available to satisfy the needs of respiring algae, decomposing plant matter, and the sediment. The excess of oxygen in deep waters gave an impression of a vast improvement in the amount of available oxygen in the entire lake, which in turn suggested that the lake had improved considerably over previous years. Ultimate confirmation of the interpretation of the 1975 "recovery" of Lake Erie as a result of an anomaly in climate was achieved in 1976 and 1977, when spring came at its normal time, more water was warmed, and Lake Erie returned to its usual state of widespread anoxia.

The cause of this apparent, short-lived improvement in Lake Erie's condition would probably still not be understood if the tool of mathematical modeling of environmental simulation had not been available. Yet, despite its merits, no other scientific technique may be as widely misunderstood by both scientist and layperson as is this one.

Much of the problem seems to lie in the absence of a common language about modeling. Since the language of mathematical simulation is unknown to the general public, to many managers, and even to a good proportion of the scientific community, the subject seems to generate feelings of apprehension and distrust.

The language that we have shared since childhood suggests that a model is a physical reality, a representation (usually in miniature) of an object. Often, this representation shows the construction, or is a copy, of the original. But while most of us can understand that meaning of "model," very few of us have been exposed to the concept of numerical simulation and the function it is intended to perform.

Reduced to its essence, a mathematical model is more than a simple organization of coefficients, equations, and computer programs—although those are the ways in which the measurements in the model are expressed and calculated. A model is a dynamic conceptual framework, a continually growing numerical idea, and if you will, a vision of the future. The environmental modeler conceptualizes a mathematical scheme in which he is able to measure existing states of the environment, to evaluate how those states are interrelated in the ecosystem, and to look forward in time and envision the state of the environment for future generations.

Just as human perception grows with the acquisition of increasingly more information, ecological modeling is a dynamic process. A scientist defines quantities of substances, events, and creatures in numerical shorthand (for ease of understanding). The modeler working with the Great Lakes system must develop a wide understanding of many disciplines in order to conceptualize the major processes at work. Because these processes are so tightly interwoven with living systems

(and because of the enormity of space and time scales), simple empirical and intuitive approaches are not adequate. The analytic approach must be iterative, growing, and dynamic if it is to include large amounts of new information.

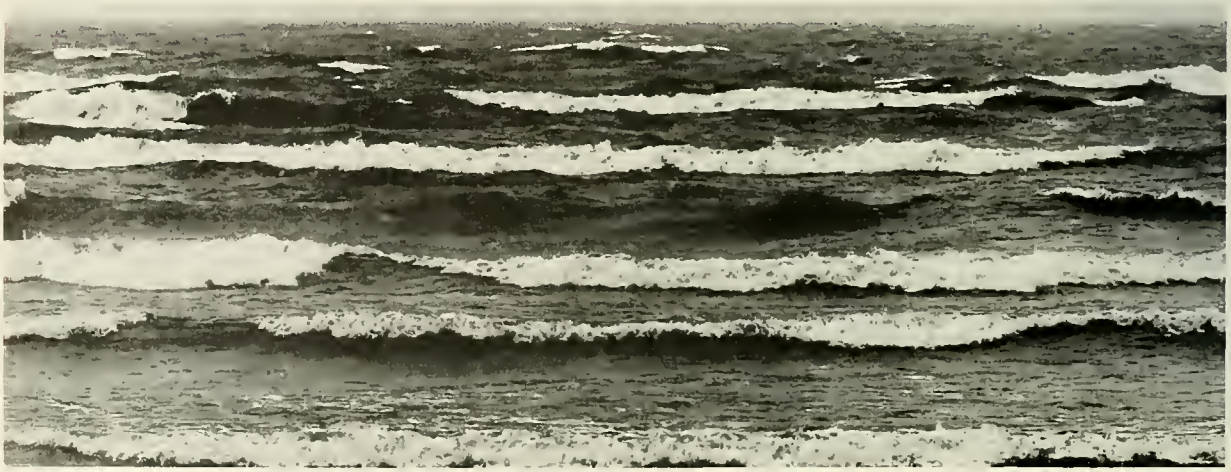
A typical modeling program might begin in the Great Lakes with the simplest of all approaches—the mass balance model. "Everything has to go somewhere," say the laws of conservation of energy and matter. The mass balance model is meant to define the manner in which a given amount of a substance goes from one place to another or from one physical or chemical state to another. This model can be used to analyze the change in concentration of a Great Lakes pollutant over time by considering (1) the amount of the pollutant added to the system from all sources; (2) the residence time of the water in the system; (3) the length of time the pollutant remains in the water; (4) the internal loss rate of the pollutant to the sediment and to organisms; and (5) the rate at which the pollutant is swept out of the lakes. The lakes may be regarded as a single, continuously stirred system, or they may be broken up into subdivisions either by area or by depth. Even the simplest models quickly develop an insatiable appetite for data, and additional information can expand the horizons and refinement of the model. As the conceptual system of the model becomes more complicated, the amount of data and number of solutions increase rapidly. In the larger environmental models, which relate many complex ecological events, a computer often must solve simultaneous algebraic equations for several hundred unknown entities.

Before a model can be used for prediction, two final steps—calibration and verification—must be performed. Calibration involves comparing measured data with calculated model results, then making adjustments in the model until the measured and calculated data match. Scientists then verify the model by matching calculated values with a set of independent data that were not used to develop the model. Once calibrated and verified, the model may be used to simulate the impacts of various alterations in the ecosystem and to anticipate outcomes.

In the future, Great Lakes modeling and simulation efforts can be expected to provide answers to problems that cannot be effectively attacked in a more traditional way. One of these areas of current scientific concern is that of such toxic and carcinogenic materials as pesticides, polychlorinated biphenyls, plasticizing compounds, and polynuclear hydrocarbons.

Among the questions that mathematical modeling should be able to answer are, What are the origins of these materials? How do they affect the ecosystem? What is their fate? How do they affect the food chain? If banned immediately, how long will they persist?

If one takes into account the many effects of stratification and other aspects of the seasonal cycle, retention time for water and pollutants in these huge inland seas varies from three (for Lake Erie) to five centuries (for Lake Superior). Thus, management of toxins and pollutants concerns the distant future as much as it does tomorrow. The answers to these and other questions about the lakes, when provided by mathematical models of the environment, can supply managers with the information necessary to adopt effective control policies. □



David Plowden

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WINNERS OF THE 1978 NATURAL HISTORY PHOTOGRAPHIC COMPETITION

In her best-selling book *On Photography,* Susan Sontag notes that "photography entered the scene as an upstart activity, which seemed to encroach on and diminish an accredited art: painting." She says that Baudelaire, the French poet of the mid-nineteenth century, called photography painting's "mortal enemy." Although one winner in the 1978 *Natural History* Photographic Competition does take photographs that he consults when painting, most photographers, like most artists nowadays, worry less about producing a faithful replica of a subject than about imposing their own standards upon it. Photographs illustrate their takers' precise views about light, texture, shadow, color, and form.

Americans, perennial travelers who left their roots elsewhere, are particularly enthusiastic about photography. It has been one way to grasp the spread of a new continent. "You take a camera in your hands," said one entrant, "and you start to see pictures everywhere." Perhaps this is why so many of 1978's winners are professional photographers or use cameras as tools in their daily work. Some had to travel far to find beautiful images; others found that pictures came to them between nine and five.

The three judges who selected this year's winners—from 400 slides and prints culled from approximately 40,000 entries—professed astonishment at their awesome power to award the Grand Prize that would send the winner all the way to Egypt from his Minnesota home. The 1978 judges were: Gene Thornton, contributing editor of *Art News* and photography critic for the *New York Times,* who is writing an introductory history of photography; Arthur Rothstein, one of the first photographers for the Farm Security Administration, director of photography for *Look* magazine, and now director of photography for *Parade,* a color supplement to 125 newspapers; and Cornell Capa, director of the International Center of Photography.

The judges agreed that Frederick J. Thompson deserved the Grand Prize for the dramatic story told in his sequence of photographs of the Rice Lake forest fire. In September 1976, Thompson was on a three-day solo canoe trip on the Isabella River, in the Boundary Waters Canoe Area of northern Minnesota's woods. Since he produces educational visual material, largely concerned with ecology and local history, Thompson had his camera with him. "I was on my return trip after having fought another forest fire about seventy-five miles north of this one. When I spotted a wisp of smoke I was livid, thinking that it was someone's campfire. There was a burning ban on; the woods were tinder dry. In 1976, a terribly dry year, forest fires occurred almost weekly for a while.

"The Rice Lake fire was a sleeper, started by lightning but smoldering for several days before blowing up. Within a half hour after I spotted it, the fire was crowning in the tree tops. I felt totally helpless; I was at least five hours of paddling from my van. And while I knew that the Boundary Waters Canoe Area is a fire-regenerative system, I was horrified to think that the fire would burn to the Isabella River and destroy a place that I had come to love."

When Thompson returned the following spring, however, he was able to photograph a reasonably

SPECIAL AWARD
Humor in Nature
Epidendrum parkinsonianum orchid
Manaus, Brazil
Kjell B. Sandved



happy conclusion to the story: by burning off the land, the Rice Lake fire had destroyed life, but had also brought it back to the woods.

Another view of the American north woods came to Steven Benson during an ice-fishing trip on Anchor Bay, Lake Saint Clair, Michigan. One overcast day, he photographed three fishers using a plastic sheet as a windbreak. Benson thought that his image of the three staring in silent concentration at a small hole had less to do with ice fishing than with "an existential sensibility." Isolated by their plastic sheet from their surroundings and from Benson's camera, "all three men seem to share the same fate." Benson's use of stark black-and-white film contributes to, and points up, his fishermen's icy loneliness.

Barbara Doran took this year's only other prize-winning black-and-white photograph in the Denver airport over Thanksgiving, when she had three hours to kill before catching a plane. Her solution was to watch others absorbed in pay TV. In the man-made environment of Denver's airport, Doran found an image that she related to nocturnal woodlands in other parts of Colorado. "Each person was initially drawn to the TV as helplessly as deer are mesmerized by car headlights. The entire time I watched, the overweight girl sat in the same slouched position, never stirring, eyes fixed on the side of the TV that I couldn't see."

Charlie E. Rogers, an entomologist specializing in the biology of pests, was traveling for his work when he photographed a classic Kansas image—fields of sunflowers grown for vegetable oil. Back home in Texas, Rogers had been working on developing a breed of sunflower that would resist the sunflower moth and other insects that cause diseases.

Three other scientific researchers also took prize-winning photographs in the regular course of their investigations. Biologist Jim Breeding says he'll "take a picture of anything," but his photomicrograph of a cross section of a kitten's muscles associated with the femur required considerable slide preparation and planning. This kind of photography permits Breeding to combine "three personal fascinations": the microscope's ability to reveal the body's hidden workings; the use of dyes to demonstrate a physical structure's biochemical functions; and finally, the camera's ability "to probe, capture, and relate color, function, and design."

Joan Hudson and Gerald Carner, research technologist in the electron microscope facility and associate





FIRST PRIZE
The Natural World
Humpback whale tail
Glacier Bay National Monument, Alaska
Tom Bean





professor of entomology at Clemson University in South Carolina, respectively, have been experimenting with a new technique for photographing live species. Carner had a colony of aphids that he was using in research on the transmission of virus diseases. Hudson used the vacuum within the electron microscope's chamber to immobilize a green peach aphid nymph on a mustard leaf and operated the microscope at low voltage to avoid damaging the insect.

Like Joan Hudson, Kjell Sandved, a Norwegian photographer who came to work at the Smithsonian Institution eighteen years ago, likes to study life in miniature. He is known for his nature photography and his documentaries of small creatures—notably the film *Curious Creatures and Mini-monsters*. But this is the first time that he has entered a photography contest. He crept out on a tree branch to photograph his "cow-faced" orchid, which he found near the Amazon River in Brazil, where high humidity fosters a wide variety of insects and orchids.

At the opposite end of the world, in Alaska, Tom Bean works for the National Parks Service as a seasonal naturalist at Glacier Bay National Monument, an area of protected inland waterways. Last summer, Bean and a friend did some kayaking in the bay and came upon three humpback whales feeding. When these whales surface, they take a breath before sounding, or making a deep dive, and as they dive, their tails rise at the last moment. "We paddled out amongst the whales, so close that mist from their breath fogged up my lens. Because visibility was very poor, we worried that the whales would come up under us and capsize



the kayak. But they paid us no attention, probably because they have acute hearing and we beat our paddles against the kayak to warn them we were there."

Americans have used their wanderings as a means of collecting photographs. Sometimes the search does not have to lead many miles. Kingdon Lane, who designs photographic and electronic equipment, found his two owls—"I was lucky to get one behind the other"—on a trip to New York's Staten Island Zoo. Giles Gates specializes in photographing animals, but "since nature photographs don't always sell, I do some carpentry as well. I was doing some photo work on ground squirrels and cactus wrens at the Maricopa County Zoo in Phoenix, Arizona, and as I passed the small flamingo pond, I noticed the form and color of one resting bird." At the San Diego Zoo, Forrest G. Moyer, a pediatrician who often uses photography to record medical histories, found his orangutan perched "on the highest point of his enclosure, snoozing in the sun and viewing his public. He must be used to photographers, for he seems to pose deliberately."

During more extensive traveling, according to one contestant, photography can help initiate conversation: "If you aim a camera at someone you can't help communicating with him or her." In a small village in Yemen, Evelyn Scott had to communicate with a sidelong glance. Aware that "the men of Yemen are reluctant to have their women's pictures taken," Scott photographed one striking villager with a right-angle mirror attachment.







GRAND PRIZE
The Rice Lake forest fire
Boundary Waters Canoe Area, Minnesota
Frederick J. Thompson



FIRST PRIZE
The Human Family
In a snowstorm
Highland County, Virginia
Everett C. Johnson



Nikos Anastasakos also seized what the White House press office calls a "photo opportunity" when he was struck by the "patterns of light and form delineated by the poplars along the shore" of Dal Lake in Kashmir, India. Everett C. Johnson and some fellow photographers were overtaken by an unexpected March snowstorm during a sugar maple festival in southwest Virginia. Johnson's entry skillfully included a member of the group walking along "a pleasing S-shaped curve."

Others know just what they want. Sculptor-photographer James Gardner moved to the country when his wife took a teaching job in New York State's Catskill Mountains. Gardner found that he could never return to the city again and has been concentrating on photographing several mountain trees in all seasons. He caught one tree's changing foliage on a clear autumn day. Paul Sher, a pathologist and free-lance photographer, set off down the Anhinga Trail in Everglades National Park. His entry was a sequence of an anhinga feeding. "Unlike other birds, the anhinga does not have oil glands, so it can submerge itself in water. It spears a fish with its beak, surfaces, flips the fish off its beak, and swallows it head first to avoid catching spines in its long throat."

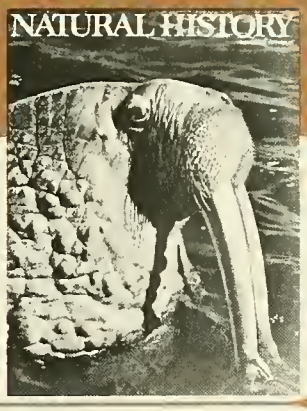
Sher and the three other First Prize winners in the four categories of the 1978 competition each won $500. The ten Honorable Mention prizes were $100 each, and the special award for Humor in Nature was $200. The 1978 Grand Prize was two tickets on the American Museum of Natural History's Discovery Tour of Egypt next winter. The three-week trip will include a two-day stop in London, followed by a leisurely cruise up the Nile River from Cairo to Aswan, with an optional flight to Abu Simbel. All 1978 prizewinning photographs will be displayed in special exhibitions—at the American Museum of Natural History in September and at the Pacific Science Center in Seattle, Washington, in November.

For the 1979 *Natural History* Photographic Competition, the categories will be: The Natural World; A Sequence of an Event in Nature; Photomicrography, including pictures with a scanning electron microscope; and The Human Environment. There will be special awards for Humor in Nature and Urban Wildlife. Details concerning the rules, the prizes, and the deadline will be announced early next year.

Ann Marie Cunningham



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FIRST PRIZE
Photomicrography
Green peach aphid nymph,
Myzus persicae, *feeding*
on a mustard leaf
Clemson, South Carolina
Joan S. Hudson
Gerald R. Carner



Honorable Mention
Flamingo
Phoenix, Arizona
Giles H. Gates

Honorable Mention
Muscle section
Los Angeles, California
Jim Breeding







FIRST PRIZE
A Sequence of an Event in Nature
Anhinga feeding
Everglades National Park, Florida
Paul Phillip Sher







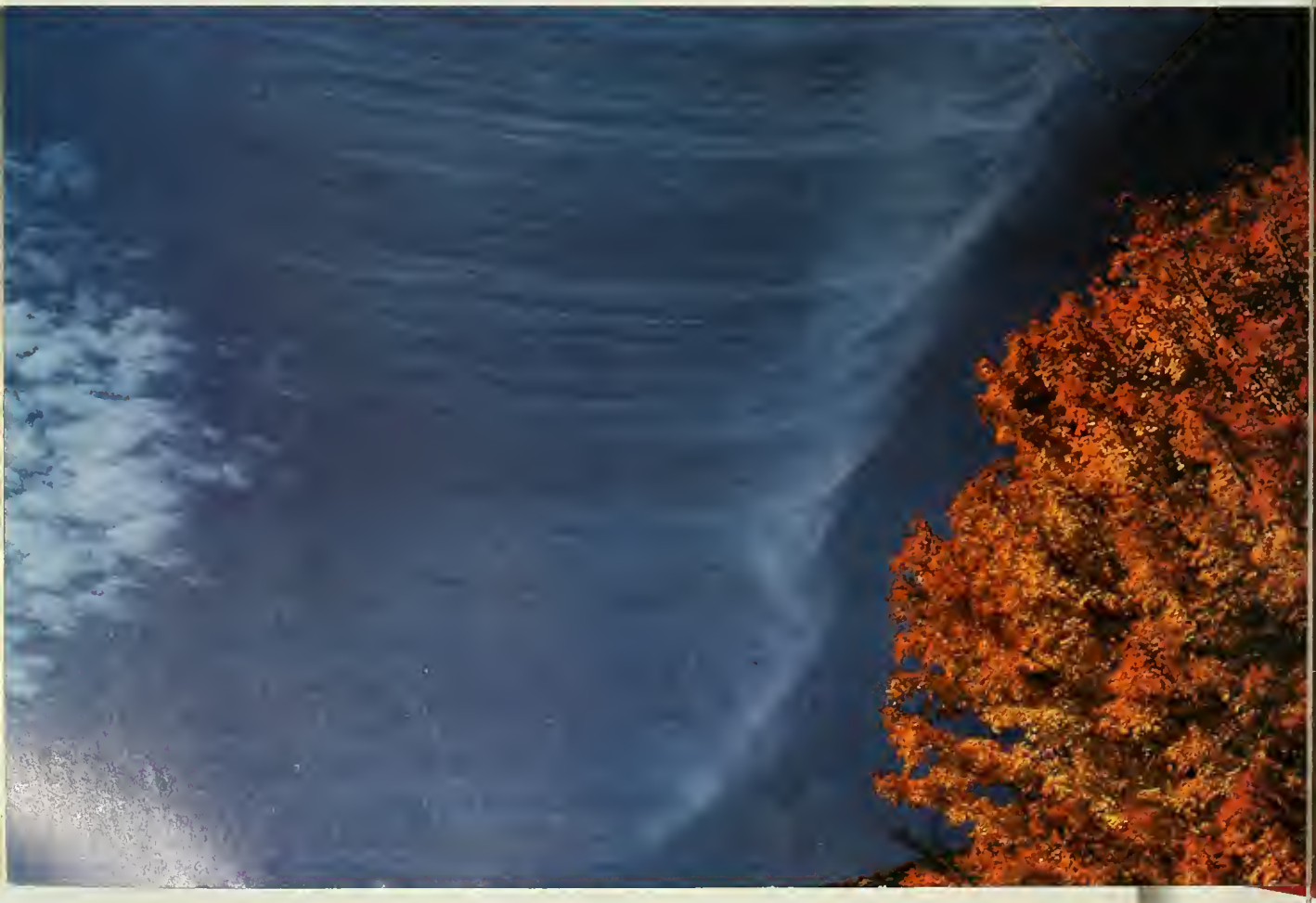
Honorable Mention
Sunflowers
Garden City, Kansas
Charlie E. Rogers



Honorable Mention
Airport waiting room
Denver, Colorado
Barbara Doran

Honorable Mention
Orangutan
San Diego, California
Forrest G. Moyer





Honorable Mention
Poplars along Dal Lake
Kashmir, India
Nikos Anastasakos



Honorable Mention
Ice fishing
Anchor Bay, Lake Saint Clair, Michigan
Steven Benson

Honorable Mention
Autumn in the Catskills
Shandaken, New York
James A. Gardner

Honorable Mention
Young woman
Mocha, Yemen
Evelyn Scott



Honorable Mention
Two owls
Staten Island, New York
Kingdon Lane



Letters

Death by Decree

I am troubled by Colin Turnbull's "Death by Decree," which appeared in your May 1978 issue. It is neither calm nor objective, although it pretends to be both. Mr. Turnbull says—after an emotional prelude setting out the essential inhumanities of capital punishment, to his mind—that "this is not an argument for or against capital punishment." Not only is this undercut before it is set out, for the bias is already clear, but (1) the arguments marshaled in favor of capital punishment are tersely and at times pejoratively stated, while those arguments that "refute" the positive ones are very elaborately developed; and (2) the pro side is remarkably thinly stated. Mr. Turnbull draws, for example, on the resources of the humanities as well as on anthropology and law—but only to emphasize the negative position from which he is writing. Might there not be some obligation to see what can be learned from, say, the sociobiologist?

The law has had a good deal of varied experience in this whole area; might it be useful to see what has been learned about redeemability, about rehabilitation, and about the comparable experiences of other criminological systems than our own, in which the notion of reforming those guilty of serious, life-threatening crimes has not been entertained? Clinical psychology has some useful and deeply pertinent insights into the pros and cons of rehabilitation too.

Unlike Mr. Turnbull, I happen to be persuaded—although I once held contrary views—that capital punishment is both desirable and necessary, given the realities of our society and also given our extremely limited abilities and resources in dealing with the antisocial. Rather than lean quite so heavily on talk of our essential "humanity," I would myself prefer to deal with our unavoidable "animality," our decisive and ineradicable links with other mammalian species. But more important than any of this, and than any of my own opinions, I would prefer that *any* writing on so important a subject as capital punishment deal with its subject, and with its readers, fairly and honestly.

Burton Raffel
University of Denver
Denver, Colorado

The article has moved us deeply. The author has done a magnificent, scholarly treatment of his subject. His humanity of spirit is inspiring. To use his superb talents in so daring a way is truly edifying. It has left an emotional impact that one cannot easily dismiss.

Rosemary Parker
Kansas City, Missouri

As an effective writer (or even an anthropologist, as he claims himself to be), Colin Turnbull should either go soak his head in a wisening solution or consult the nearest headshrinker.

John L. Price
Bozeman, Montana

This is to protest using the pages of *Natural History* to print articles such as Colin Turnbull's "Death by Decree." Mr. Turnbull is entitled to one vote on capital punishment, like everybody else. He is not entitled to a soapbox on a topic in which he has no more concern than any other citizen.

If you believe this letter is motivated by my convictions about capital punishment, you miss the whole point. I have very mixed feelings on the subject and would write exactly the same letter, perhaps more sure of my position, if Turnbull had written in favor of capital punishment.

I believe professors should not overreach themselves.

Jonathan D. Sauer
University of California,
Los Angeles, California

Simply, thank you for your article on capital punishment. My respect for your magazine and editorial policies, already high, has increased.

Joyce M. McDonough
Williamsburg, Maryland

Congratulations on the superb article on the death penalty.

Anton J. Dubrick
Peoria, Illinois

I don't know the details of Colin Turnbull's research design and data that lead him to conclude that the families of victims initially "demand vengeance," and "ultimately suffer from the knowledge that they are responsible for an ever widening circle of tragedy." For at least some families, neither conclusion holds. What happens to the murderer is a function of the criminal justice system, and the penultimate suffering is the absence of the murdered person. The death penalty can be both part of a ritual process and not devoid of demands for retribution among such peoples, for example, as the Navajo, Joluo, and Western Apache. Indeed, to speak of our own society as one in which the death penalty involves a "violent demand for retribution" is too simplistic and misleading.

Turnbull's characterization of ethnography as nearly value-free, unencumbered by theoretical considerations, lacking preconceptions of significance, and so on is similarly simplistic and misleading. Surely he is aware that increasing numbers of anthropologists do not view the ethnographic process in such fashion.

His "neutral" list of arguments for and against capital punishment is conditioned by his research design, his data, and his personal values. For example, in his discussion of the prevention of recurrence argument, he states that few of those either presently on death row or executed over the past forty

years "showed evidence they were likely" to kill again. What is the nature of that evidence? Is there not a difference between premeditated murder and, as Turnbull puts it, "crimes of the passion of a single moment"? The existing law certainly recognizes such differences, shouldn't the anthropologist? Is Turnbull prepared to risk the release through parole of a murderer who *might* kill again? Here, I suggest, is an issue for all of us to consider. I don't think current knowledge enables anything more than an informed guess.

There is no question but that the criminal justice system is less than perfect. So are all human institutions. And so are all human beings. But when Turnbull says that decisions about the death penalty are difficult and that lawyers do not unanimously agree on whether it is cruel and unusual, what he is really saying is that decisions on matters we consider important are not made on the basis of unanimity in our society, in contrast to some other societies. Our principle is majority rule.

Turnbull speaks of "perfectly good people" who, "in a moment of passion, committed a single crime." Here again he misleads the reader. He does not distinguish between premeditated murder and other kinds recognized in the law which do not carry the death penalty. He also ignores the victim, the family, and friends–whom this "perfectly good" person has doomed, in the one case, to death, and in the others, to endless bereavement and grief. Can a person be perfectly good and be guilty of murder at the same time? What if one of these perfectly good persons is released and commits another single crime of murder in another moment of passion? He speaks of atonement. How? For whom? How can a murderer in our society "fulfill the social obligations of the person he has killed"? To suggest that another

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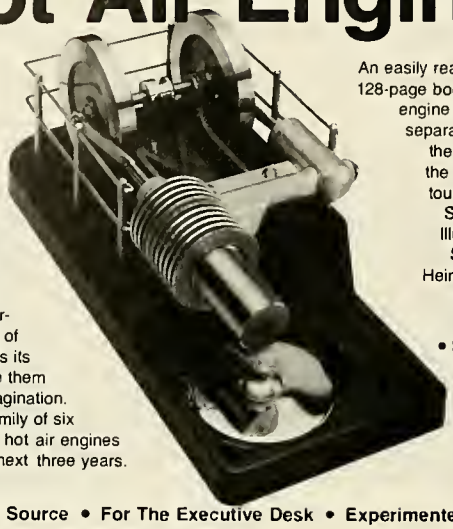
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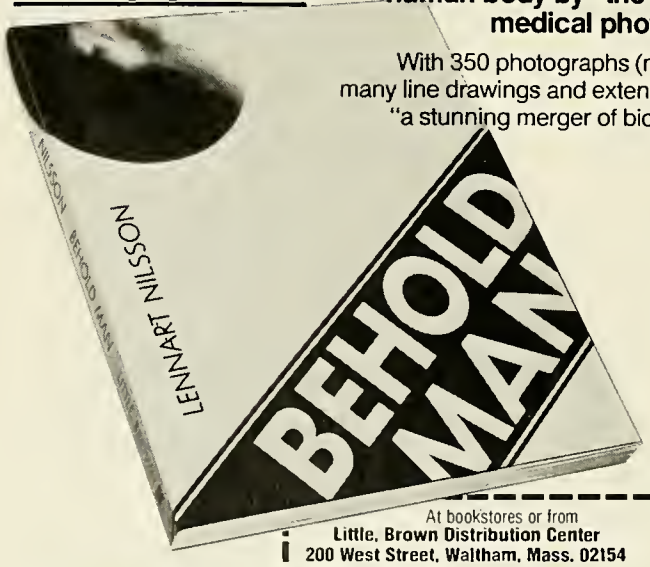
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society's practice of adopting the murderer "as a server" be considered in our society is cruel sophistry. As an anthropologist, he should know that such cultural transplants are not workable in the absence of a supporting sociocultural context.

In our society, I would suggest, the life of the individual *is* primary, and that, among other features of our culture, accounts for Turnbull's and others' real concerns about the death penalty. And that is why our criminal justice system provides for the death penalty when the murder is not a crime of the moment, but is premeditated.

GILBERT KUSHNER
University of South Florida
Tampa, Florida

I thought that social scientists, even British ones, had set aside an overweaningly maudlin concern for real criminals and adopted a more realistic view of evil men and the torment their acts cause innocent victims. So I was dismayed to read Colin Turnbull's pathetic anecdotal piece.

Those who choose to break the social contract are usually prepared to accept the consequences of their acts—hence, punishment does not equal deterrent—and society should not be chided for exacting a penalty, even if that penalty be death.

Turnbull wastes sentimentality on coldblooded murderers. While he rhapsodizes about his "good and kindly friends" suffering on death row, I think of the good and kindly friends of the victims who now lie dead of a brutalization far less sane and sanctioned than the prison and the electric chair. I am surprised that an anthropologist does not understand that penalties for wrongdoing are knit into the fabric of all cultures and that brutalizations on either side do not cancel out each other.

EDWARD J. QUIGLEY
Chicago, Illinois

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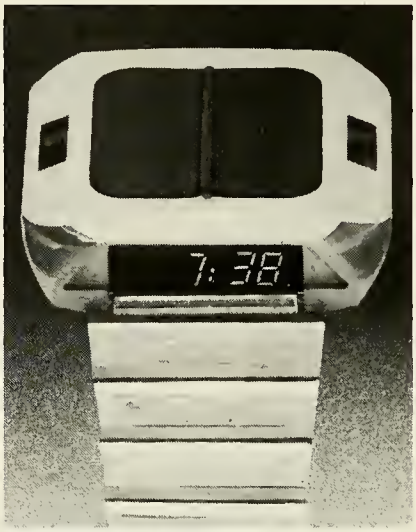
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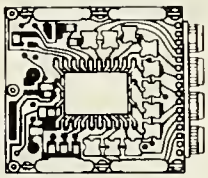
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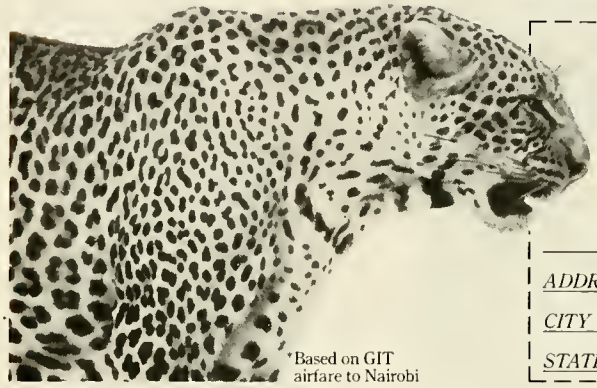
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Strange Doings on Io

This large satellite of Jupiter is the most curious of all that planet's thirteen moons

Small bodies in the solar system have become increasingly interesting objects for research in recent years. By small bodies I mean planetary satellites, the asteroids, comets, meteorites, and even small planets, such as Pluto and the newly discovered object lying between Saturn and Uranus. These bodies were probably formed at the same time as the rest of the solar system and by the same processes, but they are much less likely to have changed during the ensuing 4.5 billion years. The inner planets, for example, have been reorganized or differentiated by interior melting through the release of nuclear and gravitational energy, a process that would not occur in the same way for smaller bodies. Similarly, fluid envelopes, whether atmospheres or oceans, erode and modify the surfaces of Earth, Mars, and Venus, but smaller bodies do not have a strong enough gravitational field to hold down such envelopes. We may therefore hope that these small bodies, and particularly their surfaces, present primitive material that is closely related to events that took place when the planets were formed.

Jupiter has thirteen known satellites, four of which are moon-sized bodies easily seen through a small telescope. These are the Galilean satellites, named after their discoverer, who first observed them almost 370 years ago. This complex system of satellites is strongly reminiscent of a miniature solar system, with Jupiter replacing the sun at the center. It is difficult to avoid concluding that the processes of formation were the same for both

by Richard Goody

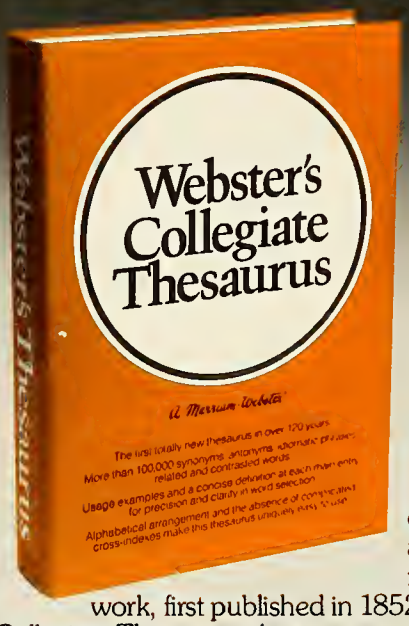
systems, so that one provides a primitive microcosm of the other.

The innermost—and strangest—of the Galilean satellites is Io. Its disk, about one arc-second in diameter, can only be resolved under quiet atmospheric conditions. A few shadowy features have been recorded, including dark-reddish polar caps. The mass of Io has been measured by standard astronomical techniques, yielding a mean density similar to the moon's. That was almost the extent of our knowledge from the first 350 years of research. But modern techniques of spectroscopy and radio astronomy, together with planetary probes, are adding new data that may ultimately lead to a deep understanding of the satellite, its surface, and the particle environment of Jupiter.

The first remarkable property of Io is its ability to modify radio waves emitted from Jupiter in the decametric band (somewhat lower in frequency than the commercial FM band). The discovery of these radio emissions in 1955 was, at the time, one of the most unexpected results to come from the new techniques of radio astronomy. But even more surprising was a later claim by an Australian meteorologist that the emission intensity was related to Io's position in its orbit. The meteorologist's interest was in the condensation of terrestrial clouds, which only adds to the bizarre character of this chapter of the Io story.

What does this tell us about Io? To answer that question we need a theory of the radio emission that involves the properties of the satellite. The most generally accepted hypothesis assumes that Io conducts electricity and thereby interacts with Jupiter's magnetic field. Incidentally, that Jupiter, like the earth, should have a strong mag-

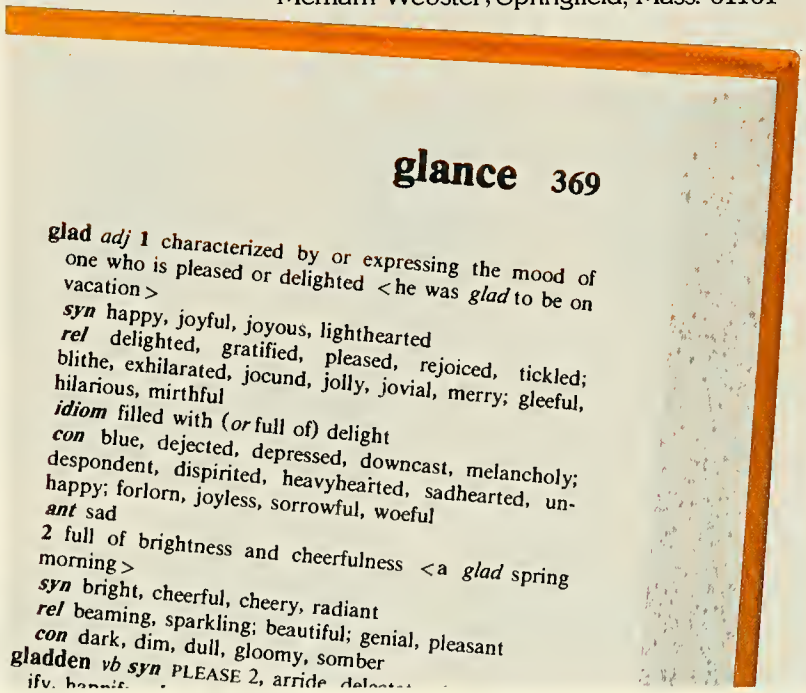
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syn happy, joyful, joyous, lighthearted
rel delighted, gratified, pleased, rejoiced, tickled; blithe, exhilarated, jocund, jolly, jovial, merry; gleeful, hilarious, mirthful
idiom filled with (*or* full of) delight
con blue, dejected, depressed, downcast, melancholy; despondent, dispirited, heavyhearted, sadhearted, unhappy; forlorn, joyless, sorrowful, woeful
ant sad
2 full of brightness and cheerfulness <a *glad* spring morning>
syn bright, cheerful, cheery, radiant
rel beaming, sparkling; beautiful; genial, pleasant
con dark, dim, dull, gloomy, somber
gladden *vb* ***syn*** PLEASE 2, arride, delect
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netic field was required to explain other features of the planet's radio emission. This conclusion was confirmed by measurements made on the *Pioneer 10* spacecraft, which flew past Jupiter in December 1973.

The same mission showed that Io was an electrical conductor or, at least, that its atmosphere was. Radio waves forming the communication link between the earth and the spacecraft were disturbed as the spacecraft passed behind the satellite. The manner of the disturbance indicated that Io has an ionosphere, an electrically conducting atmospheric layer similar to the region of the earth's atmosphere responsible for reflecting radio signals across the Atlantic. We did not need *Pioneer 10* to tell us this, however, for a few months before, the most surprising of all discoveries about Io was made by my associate Robert Brown, a planetary physicist at Harvard. He found that Io was emitting the yellow light of sodium (the same emission was used in past decades for street lighting). This discovery made possible the speculation that Io had an ionosphere in which the electrons were formed by sunlight striking atoms of sodium or that other atoms, particularly hydrogen atoms, should coexist with the sodium in Io's orbit.

Io's sodium cloud has been intensively researched for five years (it was soon established that the emission was not restricted to the disk of the satellite itself but spread some distance from it in an ex-

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Reprints of Colin Turnbull's article, "Death by Decree," with artwork by Ben Shahn, which appeared in the May 1978 issue, can be obtained by writing to Natural History, 79th Street at Central Park West, New York, N.Y. 10024. Rates per copy are:

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tended cloud). Most recently one of my graduate students completed a study of pictures of the cloud. Making a picture was a difficult task that involved the scattering of light inside the telescope itself. Telescopes are imperfect. A point source of light is seen as a finite image surrounded by a faint corona. With a bright source such as Jupiter, the corona is overwhelmingly strong compared to the weak sodium emission. It is one thing to separate the sodium light with an elaborate spectrograph; it is far more difficult to distinguish between sodium light and scattered Jupiter light in a photographic image.

My student succeeded in taking pictures of the cloud by imprinting a characteristic signature of the sodium light in the form of closely spaced grid lines crossing the cloud's image; a computer was then used to separate the striped sodium image from the unwanted scattered light. What emerged was a picture of a banana-shaped cloud of light pointing forward from the satellite (with respect to its motion in its orbit) a distance of about three Jupiter radii and oriented slightly inward toward the planet. (The circumference of Io's orbit is equal to approximately thirty-seven Jupiter radii.) The width of the banana, that is, the brightest part of the cloud, called region B, is of the order of one-third its length. There are other, weaker emissions at greater distances.

From such pictures we can make many inferences. For example, the velocity of the majority of the sodium atoms leaving the satellite is about one and a half miles per second, fast enough for them to escape from Io's weak gravitational field. The atoms survive about fifteen hours and then disappear from the cloud. A preponderance of atoms is emitted from the trailing side—paradoxically, atoms from the trailing side end up ahead of Io, and those from the leading side end up behind. Finally, the outflow of sodium from Io—even if it has continued throughout the age of the solar system—is so small that it could be supplied by a layer of sodium-bearing rocks only about ten feet thick.

The consensus about what is happening on Io is as follows. The sodium is originally combined in some compound on the surface. High-energy protons, that is, charged nuclei of hydrogen atoms, circulating in the Jupiter radiation belts, strike Io's surface and cause atoms to sputter off into space. These atoms are neutral, that is, they have lost none of their outer electrons. In this condition they can scatter sunlight in the characteristic yellow light of sodium. Exactly why the emission comes mainly from the trailing side is unclear—presumably an interaction between the protons and Jupiter's magnetic field is involved, perhaps related to the mechanism governing the modulated radio emission previously discussed.

Although the sodium atoms can escape from Io, they are now captured by the much stronger gravitational field of Jupiter, and they move around the planet, more or less in the same orbit as Io, but diffusing slowly away from it.

The size of the cloud is limited by the lifetime of the neutral sodium. About fifteen hours are required to diffuse three Jupiter radii forward in the orbit and in that time

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the probability is that the sodium will lose an electron by collision with a charged particle in Jupiter's environment. When this happens, the sodium will cease to emit its characteristic yellow light. Moreover, Jupiter's magnetic field will interact strongly with an electrically charged sodium atom and move it rapidly out of its orbit to some other place in the Jupiter system.

The story of the sodium atoms from this point onward is only partly understood. Eventually, the charged sodium atoms will recombine with electrons to form neutral atoms, which would once again scatter yellow light, but elsewhere than in the Io cloud.

I will now move on to two other topics that may or may not be related to the foregoing. One is Io's extraordinary brightness. An object may be bright because it is large, because it is close to the sun, or because it reflects strongly. It is not difficult to narrow the choice for Io. In the red and infrared spectrum, Io reflects more strongly than would a sphere covered with perfectly white, diffusely scattering material. White or even pale solid surfaces are rare in the solar system. The surface reflectivity of Mars is about 15 percent. The terrestrial oceans reflect about 6 percent of the light falling on them. Mercury and the moon reflect little more than the terrestrial oceans, and some regions of both are as dark as black paint. The overall reflectivity of the earth is close to 40 percent because the planet is half covered with clouds. Venus and the giant planets have high reflectivities for the same reason. Even though we think of Io as having an atmosphere, it is far too thin to form clouds. We might most reasonably have guessed that Io would reflect darkly like the moon and Mercury, rather than more strongly than a "perfect" reflector.

I put perfect in quotes because we must consider another factor. We only view Io in what amounts to back-reflected light. The Sun-Io-Earth angle is always small because Jupiter is far from both the sun and the earth. If light could somehow be constrained to return along the path of incidence, then a small reflection could produce a brilliant object, witness the glint of a distant mirror. But a mirror would not

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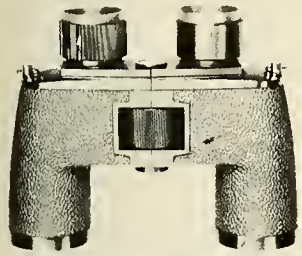
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produce the steady brilliance of Io because the satellite rotates and we would see an intermittently flashing beacon, which is not the case.

The only plausible suggestion made so far to explain Io's brightness is that its surface is covered with cat's-eyes, the type of reflector often used on traffic signs. The essence of a cat's-eye is a reflecting cube corner, which has the property of returning light in almost exactly the direction from which it comes. Although this is an improbable proposal for Io, it is all that we have to go by, and Io is such a peculiar object that it just might have cat's-eyes composed of crystalline deposits on its surface.

My final topic is sulfur, which has been detected in ionized form just inside Io's orbit. The sulfur may have nothing directly to do with Io, but it was discovered in connection with investigations of the satellite, so we may take it to be part of Io's story. The reader hardly needs to be told that this discovery was unexpected. Everything about Io seems to be so. Regardless of how it got there, this ionized sulfur emission serves an extremely useful function: it allows us to infer the density and temperature of electrons trapped in the Jupiter environment.

Jupiter's radiation belts are the only ones we have been able to investigate, other than those around the earth, and measuring them is a high priority for space missions. Until we have an orbiter in place around Jupiter, however, these measurements will be transitory; yet changes brought about with time constitute one of the most powerful investigatory tools at our disposal. Meanwhile, observations of the sulfur emission enable us to supplement sparse spacecraft data and to place short periods of intensive measurements in a historical context. The problem of imaging the sulfur cloud over short periods of time from the earth's surface is at least ten times more difficult than for sodium. That is our next target in an investigation that, year by year, seems to open up new possibilities for understanding the outer solar system.

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The Scientific Mind

EXPERIENCING SCIENCE, by Jeremy Bernstein. *Basic Books, Inc., $11.95; 250 pp.*

The biographies of scientists are often marked by a tension between descriptions of the usually prosaic lives of most important scientists and the extraordinary flights of thought that mark their work. The biographer must decide to what extent to dwell on the "merely personal" aspects of the scientist's life, perhaps in order to stimulate human interest in his subject, as opposed to analyzing and explaining the work itself.

From the standpoint of many of the subjects themselves, the path to be followed is clear. These scientists may have consciously or unconsciously chosen their careers in order to concern themselves with matters of permanent, rather than transient, interest and resent an emphasis on the latter. Einstein, for instance, in his *Autobiographical Notes*, remarks: "For the essential in the being of a man of my type lies precisely in what he thinks, and how he thinks, not in what he does or suffers." A biographer sympathetic to the motivating passions of his scientist subjects will follow this injunction in spirit if not always in detail.

Jeremy Bernstein is a theoretical physicist and author who wrote a distinguished biography of Einstein several years ago. He has also written a number of "Profiles" and other occasional pieces of scientific biography for the *New Yorker*, several of which are collected in *Experiencing Science*. Bernstein deals with an impressive array of scientists and scientific subjects, including the astronomer Kepler, the physicist Rabi, the biologists Franklin and Thomas, and in a short story somewhat in the stream-of-consciousness mode of *Ulysses*, the logician Godel. Bernstein's hallmark, both in this book and elsewhere, is his artful interweaving of explications of the scientists' work with descriptions of their lives. By this combination, Bernstein leads his readers into an understanding of some of the seemingly complicated ideas of science, without their ever knowing that this is happening to them or their being able to protest that the material is too difficult.

The centerpiece of *Experiencing Science* is a profile of I. I. Rabi, an American physicist who has had a number of related and distinguished careers. Rabi has made important discoveries in atomic and nuclear physics, has played major roles in the creation of several thriving institutions of scientific research, and was one of the main scientific advisers of the United States government in the years following World War II. It is not easy to capture all of these distinct aspects of Rabi's work; one indication of Bernstein's writing ability is that he succeeds in doing so. By allowing Rabi to express his own views in long dialogues on a number of subjects, Bernstein gives the piece a bit of the flavor of an autobiography.

He also uses this device in dealing with several other living scientists, and I found these sections of the book to be the most successful. These include similar profiles of two other scientist-authors, Lewis Thomas and Arthur C. Clarke, whose own ways with words add sparkle to this book.

In all of these longer pieces, Bernstein is expository, rather than analytic. He does not try to determine why his subjects could accomplish what they did and does not comment on the strong views they express on a variety of topics. But

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Bernstein himself does appear in several of the profiles: here to stimulate remarks on a topic of interest; there as one of the principals in an anecdote that brings out a point about science.

In several of the shorter chapters, based on book reviews, Bernstein adopts a more analytic approach and deals with more controversial scientists: Kepler, a mixture of austere mathematician and mystic dreamer; Lysenko, a proponent of the inheritance of acquired traits, who almost ruined the study of genetics in the Soviet Union; Rosalind Franklin, a British crystallographer whose role in the discovery of the helical structure of DNA has become a matter of heated dispute. In these chapters, Bernstein does evaluate the works and views of his subjects and takes definite stands on the controversial issues.

One of the issues that Bernstein faces head-on is who deserves the credit for understanding the double helix structure of DNA, generally given to Crick and Watson. Watson has given his own view of the history of this discovery in *The Double Helix*, which, in spite of a final epilogue to the contrary, is rather supercilious about Franklin's work. Anne Sayre, a friend of Franklin's, has, in her book *Rosalind Franklin and DNA*, made a strong effort to swing the pendulum in the other direction and to show that Crick and Watson used Franklin's observations and ideas without giving her proper credit. Bernstein, relying on *The Path to the Double Helix*, Robert Olby's scholarly survey of these discoveries, has little trouble in showing that Sayre's thesis is highly exaggerated. I would have drawn the further conclusion, based on this and other incidents, that such disputes over scientific priorities are both commonplace and invariably demeaning to all parties involved—the scientists and their champions.

While it is impossible to expect the protagonists to be unconcerned about who gets the most credit for a discovery, one might decently hope for more forbearance on the part of those one step removed. Otherwise, the real story of scientific discovery is being distorted by magnifying those personal elements that are least relevant to it at the expense of those objective elements that are its essence. It is good to

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have a commentator like Bernstein to make some sort of judgment among priority claims, but it would be better yet if there were no need for such judgments at all.

The final section of *Experiencing Science* is not strictly biography, although it does relate some elements of the life and work of three men who had important roles in twentieth-century mathematics—Alan Turing, John von Neumann, and Kurt Godel. Bernstein describes the aspects of their work that involve the possibility that certain mathematical activities can be reduced to a form sufficiently simple to be carried out by computers or by human beings following a rigid set of fixed rules. Turing, working before much in the way of actual computers existed, was able to show that, in principle, a "universal" computer could be devised that could carry out any program written for it and so solve any mathematics problem that could be reduced to a definite set of steps. But one would be wrong in thinking that this would include all mathematics problems.

This limitation is due to a result originally obtained by Kurt Godel in 1931. He was working on a seemingly different question. Can a set of axioms be found from which all the theorems of arithmetic can be derived and which can be proved consistent? Godel showed that there was no such set of axioms; that any axiom system with which it is possible to derive all of arithmetic also contains theorems that cannot be proved within the system, including the theorem that the axiom system contains no contradictions. In essence, Godel's result indicates that some aspects of mathematics cannot be captured by formal axiom systems. Turing was able to prove that a similar result holds for computers: theorems exist whose proof cannot be reduced to a formal program suitable for a computer. In this sense, computers are no better off than human mathematicians but also no worse off.

Godel's theorem, let alone its proof, is not easy to understand, even a half century later. Bernstein approaches it almost whimsically, through a short story in which he muses on how to explain Godel to a visiting lady friend. Such a use of fiction as a vehicle to explain complex abstract ideas is un-

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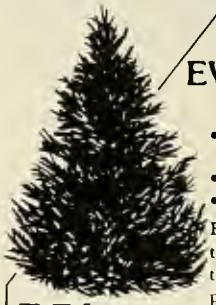
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common. An example can be found in some of Jorge Luis Borges's writing, to which Bernstein's story *Godel's Theorem* bears some resemblance. I think that on the whole Bernstein's attempt to explain Godel's work is successful as exposition of mathematics, although I am not sure that the use of a short story to do this is more effective than direct explanation. It will be interesting to see how readers react to this approach.

The variety of topics discussed and the felicity of their treatment insure that almost anyone with an interest in science will get pleasure from reading *Experiencing Science*. Scientists can learn some ideas and opinions of their colleagues that do not come through in technical articles; nonscientists can get insights into some of the important discoveries of science, expressed in a way they can understand. Bernstein's real accomplishment is to have made all this possible with one book.

Gerald Feinberg is professor of physics at Columbia University and author of What Is the World Made of: The Achievements of Twentieth Century Physics.

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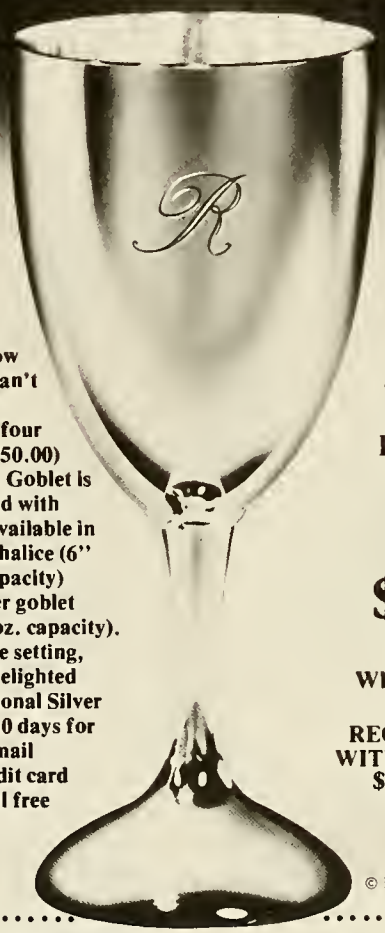
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Additional Reading

Great Lakes—General Reading

Louis Agassiz wrote one of the first natural histories of the Great Lakes, *Lake Superior: Physical Character, Vegetation, and Animals, Compared with Those of Other Similar Regions* (Boston: Gould, Kendall and Lincoln, 1850), which can still be found in many libraries. In *Superior: Portrait of a Living Lake* (New York: Harper and Row, 1970), Arno Karlen has combined excerpts from journals, diaries, and other writings, dating from 1650 to 1880, with Charles Steinhacker's large, color photographs. The five volumes of "The American Lakes Series," edited by Milo M.-Quaife (Indianapolis: Bobbs-Merrill Co., Inc.), can usually be found under the individual authors: Harlan Hatcher, *Lake Erie,* 1945; Arthur Pound, *Lake Ontario,* 1945; Grace Lee Nute, *Lake Superior,* 1944; Milo M.-Quaife, *Lake Michigan,* 1944; and Fred Landon, *Lake Huron,* 1944.

Some popular, anecdotal histories are: *The Long Ships Passing: The Story of the Great Lakes,* by Walter Havighurst, illustrated by John O'Hara (New York: The MacMillan Publishing Co., 1975); Russell McKee's *Great Lakes Country* (New York: Thomas Y. Crowell Co., Inc., 1966); *Blue Water Boundary: Epic Highways of the Great Lakes and the Saint Lawrence,* by Alida Milkus (New York: Hastings House, Publishers, Inc., 1960); and Clever F. Bald's *Michigan in Four Centuries* (New York: Harper and Row, rev. ed. 1961).

The influence of the conflict between the elements and human activities—cities, industries, fishing, shipping, and mining—on the environment can be seen in *The Faces of the Great Lakes,* photographs by B. A. King, text by Jonathan Ela (San Francisco: Sierra Club Books, 1977). Other large picture books are *Superior: The Haunted Shore,* photographs by Bruce Litteljohn, text by Wayland Drew (Toronto: Gage Publishing Limited, 1975); *Michigan,* photographs and text by Stan Osolinski (Portland: Graphic Arts Center, 1977); and *Pictorial History of Michigan: The Early Years* (1967) and *Pictorial History of Michigan: The Later Years* (1969), by George S. May (Grand Rapids: William B. Eerdmans Publishing Co.). *Paddle to the Sea,* by H. C. Holling (Boston: Houghton Mifflin Co., 1941), is a colorfully illustrated children's book about the adventures of a woodcarving of an Indian on its way to the ocean in a miniature canoe.

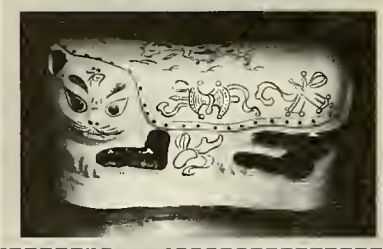
Two periodicals for the general reader are *Inland Seas: Quarterly Journal of the Great Lakes Historical Society* and *The Michigan Natural Resources Magazine* (a bimonthly). The latter had a particularly interesting article, "Who Owns the Great Lakes?" by Jack D. Bails (May–June 1975, pp. 5–9).

Props and Actors (p. 50)

Three paperback books by G. E. Hutchinson under the general title *A Treatise on Limnology* (New York: John Wiley and Sons, Inc., 1957) cover the subject extensively. Volume 1 consists of *Geography and Physics of Lakes* and *Chemistry of Lakes;* volume 2 is an *Introduction to Lake Biology and the Limnoplankton.* R. G. Wetzel's



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Limnology (Philadelphia: W. B. Saunders Company, 1975) is an undergraduate text that devotes 64 of its 743 pages to a bibliography.

Algae (p. 59)

A recent collection, *Coupling of Land and Water Systems: Ecological Studies, Volume 10,* edited by A. D. Hasler (New York: Springer-Verlag, Inc., 1975), contains reports on the influences landscapes have on water bodies and water quality and the feedback processes through which aquatic systems act on land. One chapter on "Silica and Nitrate Depletion as Related to Rate of Eutrophication in Lakes Michigan, Huron, and Superior" (pp. 277–98), by C. L. Schelske, studies the causes of plankton changes in the upper Great Lakes.

Twelve years earlier, *Limnology in North America* (Madison: University of Wisconsin Press, 1963), a multiauthored work edited by D. G. Frey, attempted to bring together important topics in limnology. On pages 535 through 558 of this volume, "The Saint Lawrence Great Lakes," by A. M. Beeton and D. C. Chandler, discusses plankton and briefly summarizes the literature on Great Lakes research from 1850 to 1966. An article on changes in Lake Michigan's ecosystems, "Eutrophication, Silica Depletion, and Predicted Changes in Algal Quality in Lake Michigan," by C. L. Schelske and E. F. Stoermer, appeared in the July 30, 1971, issue of *Science. Scientific American* (November 1966, pp. 94–104) published "The Aging Great Lakes," by C. F. Powers and A. Robertson, an article on the physical and biological processes that will eventually cause the extinction of the Great Lakes. Three scientific papers on eutrophication in the Great Lakes are: "Phytoplankton Assemblages as Indicators of Water Quality in the Laurentian Great Lakes," by E. F. Stoermer (*Transactions of the American Microscopic Society,* vol. 97, 1978, pp. 1–16); "A Summary and Comparison of Nutrients and Related Water Quality in Lakes Erie, Ontario, Huron, and Superior," by H. F. H. Dobson, M. Gilbertson, and P. G. Sly (*Journal of the Fisheries Research Board of Canada*, vol. 31, pp. 731–38); and "A Comparative Review of Phytoplankton and Primary Production in the Laurentian Great Lakes," by R. A. Vollenweider, M. Munawar, and P. Stadelmann (*Journal of the Fisheries Research Board of Canada,* vol. 31, no. 5, pp. 739–62).

Bald Eagles (p. 62)

Although out of print, *Eagles, Hawks and Falcons of the World,* by Leslie H. Brown and Dean Amadon (New York: McGraw-Hill Book Co., 1968), is available in some libraries. This biology of birds of prey is in two volumes with many color plates. *Eagles of the World* (New York: Universe Books, 1976) describes physical and behavioral characteristics, development of young, and the need for conservation. A nontechnical work on the biology and current status of bald eagles is *Autumn of the Eagle,* by George Laycock (New York: Charles Scribner's Sons, 1973). How DDT affects eggshells is explained in a *Scientific American* article, "Pesticides and the Reproduction of Birds," by David B. Peakall, April 1970, pp. 72–78. "The Bald Eagle Bicentennial Blues," by David R. Zimmerman (*Natural History,* January 1976, pp. 8–16), continues the story, adding gunshot to the list of eagle killers. The minimum productivity figure of 0.7 young per pair per year comes from "Comparative Productivity of Six Bald Eagle Populations" (*Transactions of the Thirty-eighth North American Wildlife and Natural Resources Conference,* vol. 38, pp. 96–106), by Alexander Sprunt, IV, et al. "A Great Lakes Tragedy," by Michael Gilbertson (*Nature Canada,* January–March 1975, pp. 22–25), also addresses the effects of pesticides and other toxicants on fish-eating birds.

Decline of Lake Plants (p. 66)

In his article, Ronald Stuckey mentions his fieldwork in Put-in-Bay's harbor. The study resulting from this fieldwork, in which he compares his findings with the records of Pieters, Moseley, and other botanists, was published in 1971 in the *Ohio Journal of Science* (vol. 71, no. 6, pp. 321–42) as "Changes in Vascular Aquatic Flowering Plants During 70 Years in Put-in-Bay Harbor, Lake Erie, Ohio." References to publications of the other botanists can be found at the end of the *Ohio Journal of Science* article. Two books on aquatic plants are *Common Marsh, Underwater and Floating-leaved Plants of the United States and Canada,* by Neil Hotchkiss (New York: Dover Publications, Inc., 1972), and *The Biology of Aquatic Vascular Plants,* by C. D. Sculthorpe (New York: St. Martin's Press, Inc., 1967).

Pollutants from the Sky (p. 70)

The chemical and physical characteristics of six cores from Lake Erie are described in "Cultural Impact on the Geochemistry of Sediments in Lake Erie," by A. L. W. Kemp et al. (*Lake Erie in the Early Seventies. Journal of the Fisheries Research Board of Canada. Special Issue,* vol. 33, no. 3, pp. 440–62). "Records of Lead Deposition in Lake Michigan Sediments Since 1800," by D. N. Edgington and J. A. Robbins, can be found in *Environmental Science and Technology* (vol. 10, pp. 266–74).

Thirsty Society (p. 76)

The complete *Proceedings of the Second Federal Conference on the Great Lakes* was produced by the Public Information Office of the Great Lakes Basin Commission. The purpose of this 1975 conference was to determine the current status and future needs of research related to the impact of energy conversion on the Great Lakes.

Salmon (p. 80)

Scientific background can be found in three reports written by Stanford H. Smith: "The Future of Salmonid Communities in the Laurentian Great Lakes" and "Factors of Ecologic Succession in Oligotrophic Fish Communities of the Laurentian Great Lakes" were published in the *Journal of the Fisheries Research Board of Canada,* vol. 29; "Application of Theory and Research in Fishery Management of the Laurentian Great Lakes" appeared in *Transactions of the American Fisheries Society* (vol. 102, no. 1). In 1971, a symposium on "Salmonid Communities in Oligotrophic Lakes" was held to study eutrophication, fisheries exploitation, and the introduction of exotic fish species. The proceedings, compiled by H. A. Regier and K. H. Loftus, ran in the *Journal of the Fisheries Research Board of Canada* (vol. 29, no. 6, pp. 611–986).

"You'll Always Get Home" (p. 88)

The findings of a sixty-year study

on the problem of fluctuations in fish abundance are summarized in *The Western End of Lake Erie and its Ecology*, by T. H. Langlois (Ann Arbor: Joseph W. Edwards Brothers, Inc., 1954). Two reports available from the Great Lakes Fishery Commission are "Commercial Fish Production in the Great Lakes, 1867–1960" and "Technical Report No. 3" (1962).

Computerized Ecosystem (p. 95)

For a general introduction to solving biological problems in mathematical terms see Maynard J. Smith's *Mathematical Ideas in Biology* (New York: Cambridge University Press, 1968). A classic first published in 1924, *Elements of Mathematical Biology*, by A. J. Lotka (New York: Dover Publications, Inc., 1957), is still an excellent source of ideas. Two current books on environmental modeling are R. V. Thomann's *Systems Analysis and Water Quality Management* (New York: McGraw-Hill Book Co., 1974) and *Systems Approach to Water Management*, by A. K. Biswas (New York: McGraw-Hill Book Co., 1976).

Organizations to Contact

There are a number of agencies that will answer questions and send information on various aspects of the Great Lakes. Among them are:

Great Lakes Fishery Commission
1451 Green Road
Ann Arbor, Mich. 48105

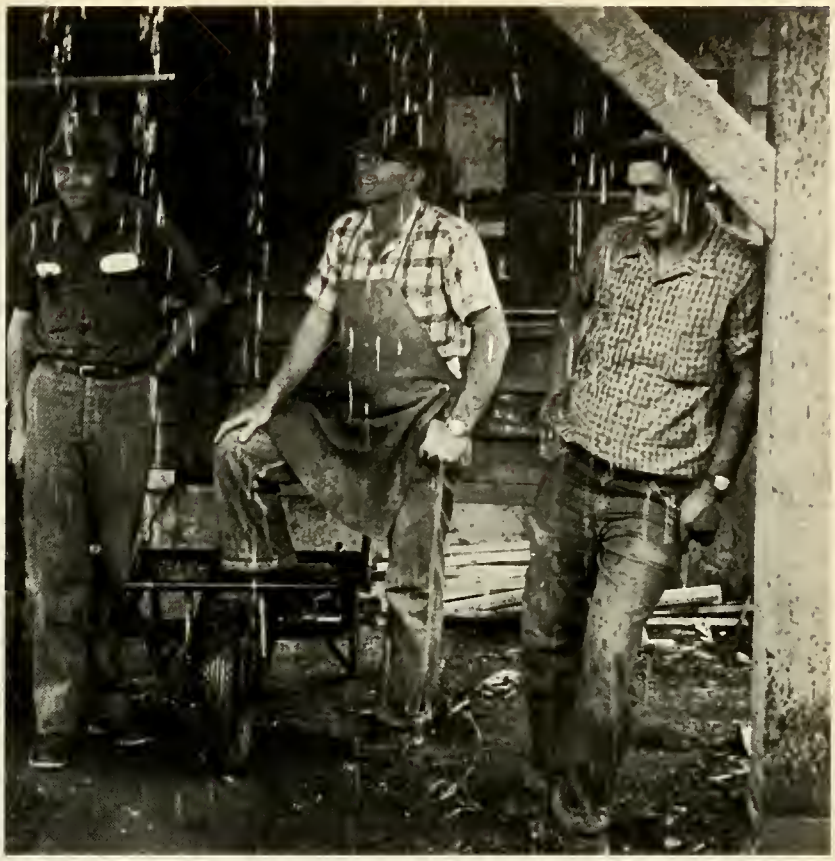
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2300 Washtenaw Avenue
Ann Arbor, Mich. 48104

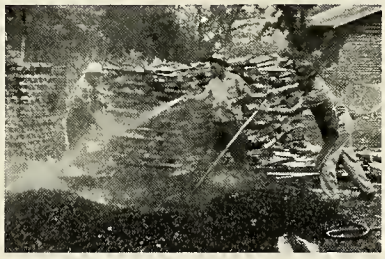
Great Lakes Laboratory
State University College, Buffalo
1300 Elmwood Avenue
Buffalo, N. Y. 14222

Katharine D'Agosta

ERRATUM: In "George Edwards: Depictor of 'Nondescripts' " (May 1978), the caption on page 81 should have read: Copies of Edwards's ring-tailed lemur, ruffed lemur, mongoose lemur, and weasel lemur, by Buffon.



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Celestial Events

Thomas D. Nicholson

Sun and Moon The sun is moving east through the stars of Cancer in early August, entering Leo on the 10th, passing just below the star Regulus on the 23rd, and nearing the planet Saturn on the 27th. On September 16, the sun moves into the constellation Virgo, where it remains until the end of October. On September 23, it crosses above the earth's equator, from north to south, at 4:26 A.M., EST. On the 27th, day and night will be equal, that is, the interval from sunrise to sunset will be twelve hours.

New moon occurs near the beginning of each month and full moon near midmonth, resulting in an evening moon the first half of August and September; a morning moon the last half. Phases are:

	August	September	October
New Moon	3	2	2 and 31
First-Quarter	11	9	9
Full Moon	18	16	16
Last-Quarter	25	24	23
Apogee	1 and 29	26	23
Perigee	17	14	11

Stars and Planets Evening planets are poor this summer, in contrast to our spectacular spring. Mars and Venus are still evening stars, but Mars is dim and sets too early. Venus is bright and easily seen in the sunset glow but appears low and sets early. Daytime viewing of Venus is good from late August to early October. Jupiter shows up as a bright morning star by late August and gets better in September; Saturn rises before dawn by late September. Mercury is also a morning star for the first ten days of September.

August 7–8: Be sure to look at the crescent moon, Venus, and Mars this evening, shortly after sundown. You will seldom see the moon closer to Venus. It covers the two planets during the night.

August 10–14: Look for the famous Perseid meteor shower any night, from about midnight on. Best on the 12th (up to 50 per hour), but you should see 20 or more shower meteors per hour, some very bright, two or three mornings before or after the 12th.

August 14: Venus and Mars are in conjunction.

August 17–18: The perigee moon will enhance the effect of the spring tide associated with the full moon of the 18th.

August 18: Mercury enters the morning sky.

August 27: Saturn becomes a morning star.

August 29: Venus is at greatest elongation (distance from the sun) as an evening star.

September 4: Mercury is at greatest elongation in the morning sky.

September 5–6: The crescent moon passes near Mars and Venus.

September 16: Harvest moon.

September 21–22: The occulation of Aldebaran by the moon is visible in North America beginning shortly after 6:00 A.M., EST.

September 23: Autumn begins in the Northern Hemisphere.

September 26: The moon is near Jupiter this morning.

September 30: Mercury enters the evening sky.

October 2: Partial solar eclipse in southern Europe and Asia.

October 3: Venus is at greatest brilliancy.

October 4: Venus is near the moon tonight.

October 16: Hunter's moon.

★Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 1:20 A.M. on August 1; 12:25 A.M. on August 15; 11:20 P.M. on August 31; 10:20 P.M. on September 15; 9:20 P.M. on September 30; and 8:20 P.M. on October 15; but it can be used for an hour before and after those times.





Helmut Wimmer



A finely carved wolf mask made by an Indian artisan at the restored Skeena village of 'Ksan.

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At the Museum

From September 13 through 17, the Museum will hold its second, annual Margaret Mead Film Festival. Inaugurated last September in honor of Mead's seventy-fifth birthday year, the 1978 festival will include more than one hundred anthropological films. They will be shown continuously in various parts of the Museum on Saturday, September 16, and Sunday, September 17, and will be free to all visitors who pay the Museum's discretionary admission fee.

The 1978 festival will honor Argentine filmmaker Jorge Preloran. In a ticketed series on the evenings of September 13 through 15, Preloran will show several of his films and discuss his work. Margaret Mead will join Preloran on two nights and Malcolm Arth, curator of education at the Museum, will moderate all three evenings.

Jorge Preloran was born in Argentina forty-five years ago but learned his filmmaking craft at UCLA. Until *Imaginero* ("The Image Man"), which he regards as one of his two most important films, was first shown publicly in Buenos Aires in 1969, he enjoyed almost no professional recognition. "For most of my life," he explains, "I had been very unsociable. I was asthmatic until I was 22. I went to the United States to study [architecture and filmmaking] and was always alone. I was married briefly for a couple of years, then lived alone for eleven years, mostly traveling about in a Jeep, making film portraits of rural people in remote parts of Argentina.

"In 1960, when I was making my early films on folklore in Argentina, I was convinced that my approach was completely objective, that I was not becoming involved at all, but remained always a neutral observer." But since Preloran began making films about individuals, he has found that he can no longer pretend to cool objectivity. "I cannot make documentaries about individuals whom I do not love and respect. The involvement with the character, his family, the stress under which they live, the problems and anguish of their daily routine sooner or later permeate my own life and make the films totally subjective." Preloran believes in making a film for his subjects and has no wish to present so-called primitive peoples in a manner palatable to sophisticated audiences.

During the ticketed screenings, Preloran will show his 1978 film, *Zerda's Children,* about a woodcutter and his family of ten children, and *The Warao* (1974), a portrait of a Venezuelan Indian tribe, hunters and fishermen who live in stilt huts along the Orinoco River's waterways. Both films, which Preloran calls "documents of human geography," attempt to describe how people survive in a particular region. Preloran will also show *Imaginero*, a portrait of Hermogenes Cayo, an Indian folk artist living in the high, barren plateau of the Puna, in northwestern Argentina near the Bolivian border; Cayo carved religious images—shrines, saints, Virgins, Christs—from cactus root, and his brightly painted work, combining Inca and Spanish

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THE CALL OF THE MINARET: The Culture of Morocco—8 Thursdays starting October 19, 7:30-9:00 p.m. Fee: $40.

In these lectures the role of Morocco in the history of the Mediterranean will be discussed. Using color slides, Paul J. Sanfacon, Lecturer in Anthropology at the Museum, brings to this series his long experience with the peoples of Morocco, where he leads the Museum's Field Study Tours. The imperial cities of Fes, Marrakech, Rabat and Meknes are contrasted with the brilliantly varied mosaic of Berber tribal life.

BALI: ISLAND OF THE GODS—Thursday and Friday, October 5 and 6, 7:30 p.m. Fee: $14.

Two evenings focusing on the culture and performing arts of Bali. Balinese music and dance demonstrated. Special guest Dr. Margaret Mead uses films to discuss Bali yesterday and today. Hosted by Beryl Bernay, photographer who accompanied Dr. Mead on her visit to Bali in 1977.

CENTRAL PARK: New York's Remarkable Back Yard—4 Mondays starting October 16, 7:00-8:30 p.m. Fee: $20.

Author Elizabeth Barlow, Executive Director of the Central Park Task Force, takes you on a slide tour of Central Park's history and natural history.

FORAGING FOR DINNER: Identifying, Collecting and Preparing Wild Foods—8 Tuesdays starting October 17, 7:00-8:30 p.m. Fee: $40.

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GREAT AMERICAN WILDERNESS AREAS—8 Tuesdays starting October 17, 7:00-8:30 p.m. Fee: $40.

Much of the remaining scenic grandeur and wildlife of the United States and Canada is now restricted to federally preserved areas such as National Parks, Monuments and Wildlife Refuges. Using color slides, Kenneth A. Chambers, Lecturer in Zoology at the Museum, introduces some of the most beautiful and diverse of these regions.

INSECTS: Earth's Most Successful Animals—6 Thursdays starting October 19, 7:00-8:30 p.m. Fee: $30.

Alice Gray of the Museum's Entomology Department gives an informal series of slide-illustrated talks on some of the fascinating aspects of the world of insects.

WILD FLOWERS OF THE ATLANTIC SEABOARD—6 Thursdays starting October 19, 7:00-8:30 p.m. Fee: $30.

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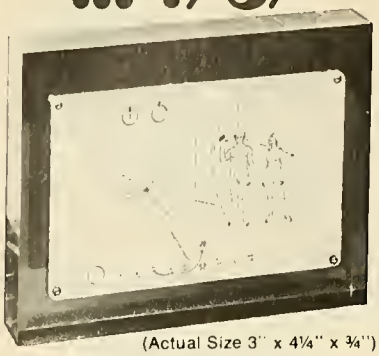
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Advance Registration is requested but registration will be accepted on the opening night if the course is not filled.

No single admission tickets will be sold.

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influences, gives this film great visual beauty. Preloran sees his work as "giving a voice to remote rural people who have none" and feels that the more important part of *Imaginero* is the self-revelation on the sound track—Cayo himself describing his life.

Another Preloran work, *Araucanians of Ruca Choroy* (1971), a film portrait of an Indian tribe, will be part of the Museum's unticketed weekend program. Films shown in Museum areas with seating—the Auditorium, Education Hall, and the Hall of Asiatic Mammals—will concentrate on three themes: Ceremonies and Celebrations, Families, and Personalities. The last will include portraits of individuals from many cultures. Preloran's film fits this category, as does a film portrait of Margaret Mead made last September by Jean Rouch, the French ethnographic filmmaker honored by the 1977 festival. Rouch took advantage of his visit to New York to film Mead in her office, walking through the Museum and along Central Park, and talking of her Museum career and her life.

Mead herself will present two special programs in the Auditorium. On Saturday, a forum on trance will include films of ceremonies involving trance in Bali and Indonesia, as well in the South Bronx. Her Sunday program, "Truth and Fact in Film," will ponder whether presentation of "facts" is the best cinematic method of arriving at "truth."

The best way to learn about the film weekend is to pick up a program, which includes complete listings of films and times and several short articles about the festival. Programs for the second annual Margaret Mead Film Festival will be available at Museum information desks starting the first week in August. Series tickets for the three evenings with Jorge Preloran cost $15 ($13 for Participating, Donor, and Life members, and for students with an ID card). For ticket information, call (212) 873-3568 or (212) 873-3698.

Ann Marie Cunningham

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October 1978

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Authors

A medical doctor, **Laurence E. Karp** is associate professor of obstetrics and gynecology at the University of Washington School of Medicine. He is affiliated with the university's Gene Center, where a group of investigators interested in genetics work together on teaching and research projects. Karp is also director of education for ob/gyn for residents, interns, and medical students rotating through Swedish Hospital in Seattle. Besides conducting research on chromosomal errors in embryos, he has published a book on genetic engineering and a collection of stories, *The View From the Vue*, about his experiences as a student, intern, and resident at Bellevue Hospital in New York City.





Trained in linguistics, **John Baugh** writes that "this training has considerably influenced the manner in which I have chosen to study handshakes." Baugh, who teaches sociology and anthropology at Swarthmore College, Swarthmore, Pennsylvania, happened to observe the "style shift" of handshakes while a lifeguard at a Los Angeles swimming pool. "The lifeguard contacts I developed proved to be most useful in establishing a rapport with prospective informants, and people thought of me as a lifeguard first and a researcher second."

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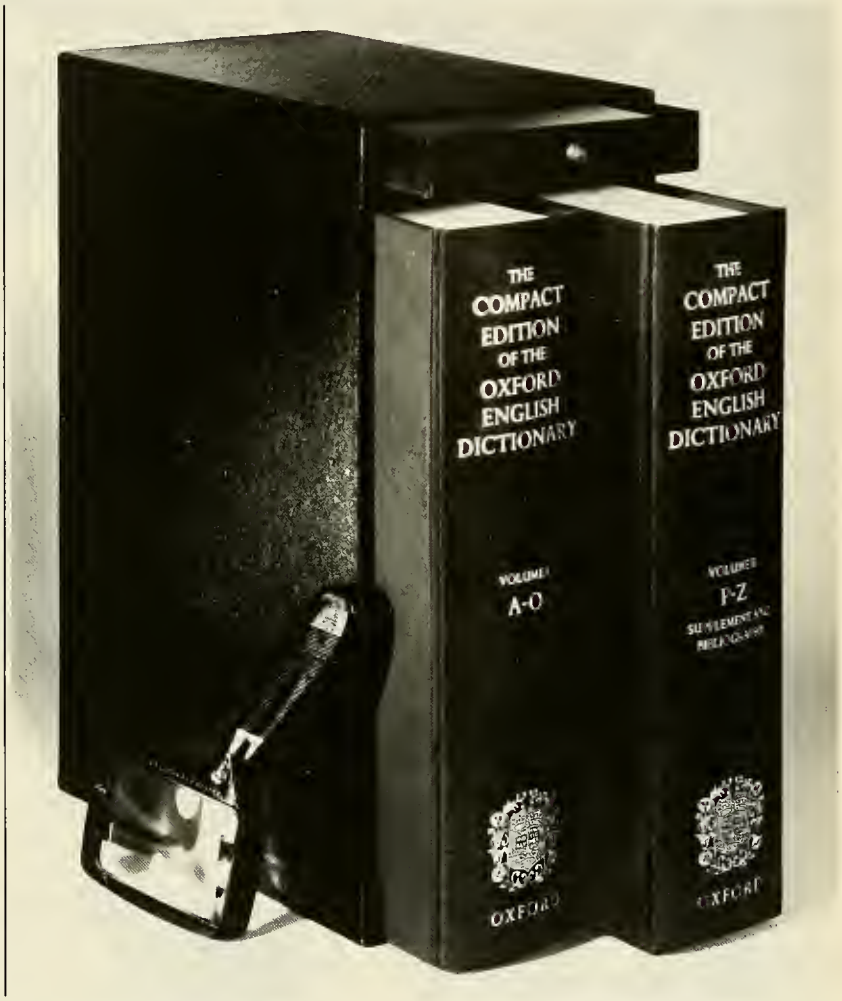
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Dorothea Scott Whitten is research associate at the Center for Latin American and Caribbean Studies at the University of Illinois at Urbana, where her husband and coauthor, **Norman E. Whitten, Jr.**, is professor of anthropology. Together they founded the Sacha Runa Research Foundation, which coordinates studies of the Canelos Quichua and Achuara Jivaroan peoples of eastern Ecuador. Norman Whitten is currently studying

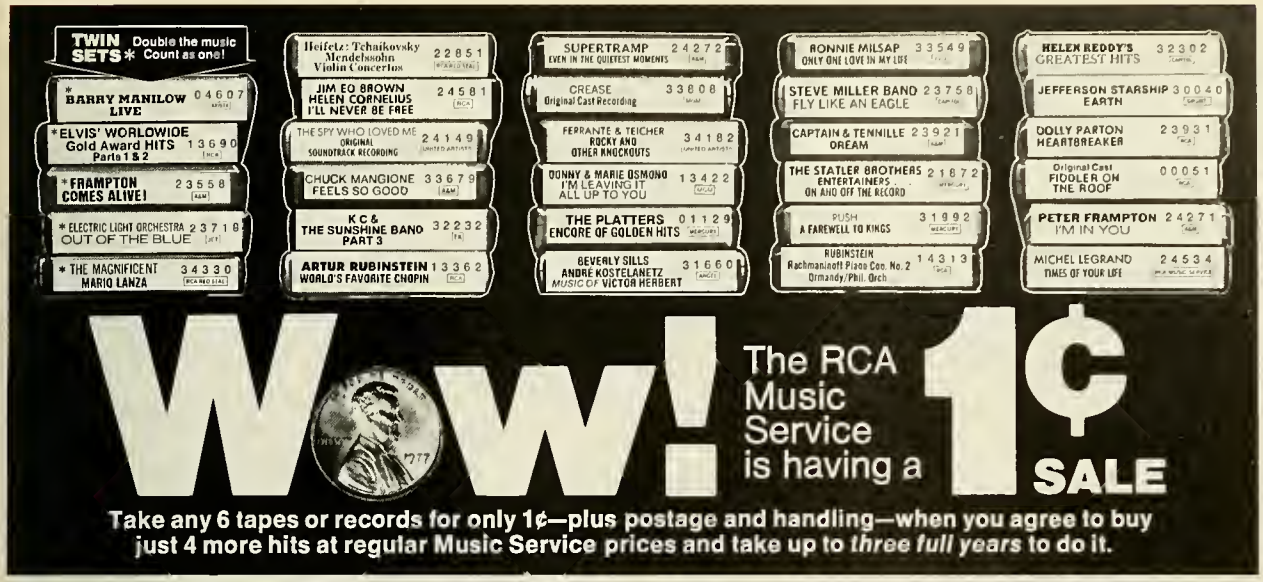




the religion, social structure, and ecology of the Canelos Quichua. Dorothea Whitten was studying the tribe's children, but says "the women increasingly involved me in problems of health care delivery, while introducing me to their techniques of making ceramics." Through the foundation, the Whittens set up a program that enables these women to sell their pottery in the United States. The proceeds provide medical services for the Canelos Quichua community.



Associate director and curator of zoology at the State Museum of the University of Nebraska, as well as professor of life sciences at the school, **Harvey L. Gunderson** acquired his interest in animals at an early age. Of his robust youth in rural Minnesota, he writes, "An avowed objective was to learn the name of everything I encountered in the outdoors—birds, mammals, plants, rocks, stars. The objective was never achieved, but the attempt led to such hobbies as wildlife photography and becoming active in conservation matters." His observations of the black-tailed prairie dog were done while studying combative behavior and vocal communication in bison at the Fort Niobrara National Wildlife Refuge in Nebraska and at Wind Cave National Park, South Dakota.



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While teaching a history of biology course at the University of Alberta, in Edmonton, Canada, **Jean K. Lauber** became fascinated with the medieval period and undertook a further search into the roots of her field. Her "fieldwork" was carried out mainly in the manuscript rooms of British museums and libraries, examining English bestiaries. A professor of zoology, Lauber has done laboratory research on the influence of light on the endocrine and reproductive systems in birds and mammals. One of her research projects on intraocular pressure in owls required that she keep twelve great horned owls for study. "The birds wouldn't take mice," she says. "They demanded chicken cut up in fryer-sized pieces and served on a tray—and hissed if the service wasn't fast enough."



"An experimental physicist with an addiction to natural phenomena" is the way **Richard Goody** describes himself. Currently Mallinckrodt Professor of planetary physics at Harvard University, he was formerly director of the Blue Hill Meteorological Observatory there and then director of the Center for Earth and Planetary Physics, whose purpose "was to encourage the synthesis of knowledge over the entire field of the earth and the planets." Born in England and educated at Cambridge University, Goody has published papers on spectroscopy, astrophysics, and meteorology. Long interested in the earth's climate, he plans to do work in that field in the next few years.



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Genetic Crossroads

by Laurence E. Karp

The way genes meet at the moment of fertilization helps determine whether a normal individual will be born

No single event in any mammal's existence is as momentous as the brief process of fertilization. Much more than the penetration of an egg by a spermatozoon, fertilization consists of a series of delicately timed developments and interactions between the male- and female-derived units of heredity. During fertilization, an individual's capacity for normal existence is determined.

The steps involved in fertilization must proceed according to a strict schedule; when it varies, the new individual is permanently damaged. The harm can be lethal, resulting in miscarriage. Individuals who survive lesser injuries suffer various forms of birth defects.

Every normal mammal has gametes, or reproductive cells, whose primary function is to maintain and transmit to the next generation the normal number of chromosomes for the species. Each gamete must come to contain one-half of the characteristic chromosome number; otherwise each generation would have twice as many chromosomes as the previous one. Meiosis, or reduction division, is the process by which the chromosomal number is reduced by one-half.

In the sperm, meiosis consists of replication of the chromosomes followed by two chromosomal and cellular divisions. Thus, a single human gametic stem cell containing 46 chromosomes ends up as four mature sperm, each with 23 chromosomes. Throughout the male's reproductive life span, from puberty to senescence, spermatogenic stem cells are constantly dividing, entering into meiosis, and forming functional spermatozoa.

In the egg, the basic principle of meiosis is the same, but the process is somewhat more complex. All the ovogenic stem cells initiate the meiotic process while their female bearer is herself still a fetus. They replicate their chromosomes, then enter and remain in a period of arrest until the bearer reaches puberty. Then, each month, shortly before ovulation, one or two ova enlarge, develop, and complete the first meiotic division.

Although the chromosomes in the egg cell's nucleus divide equally, the division of the cell's protoplasm, which is the cell's material outside the nucleus, is anything but equitable. The egg cell retains almost all the protoplasm, only a tiny bit going to form the first polar body, a cell that soon degenerates and whose only apparent purpose is to serve as a means of eliminating unneeded chromosomal material. At this point, after the first meiotic division and before the second, ovulation occurs, expelling the ovum into the Fallopian tube. Here, the female gamete awaits the arrival of its male partner; it will not complete the second meiotic division unless it is first penetrated by a sperm.

No one knows exactly how sperm make their way from the vagina through the uterus and into the Fallopian tube. Once sperm touch the egg, they wriggle their way toward and into its surrounding zona pellucida, or jelly coat. Although veritable armies of spermatozoa invade the zona, ordinarily only one sperm cell attains its goal. The first sperm to get through the zona pellucida arranges itself parallel to the surface of the egg, lying against it rather than head-on. Then the sperm fuses with the membranes surrounding the egg. Actually, the egg cell, which is much larger than the sperm, engulfs the contents of the sperm, and the sperm chromosomes enter the egg protoplasm. Simultaneously, the egg extrudes a number of tiny pellets, called cortical granules, into the zona pellucida. These pellets probably make the egg impermeable to other spermatozoa.

Once the sperm has penetrated the egg and entered the protoplasm, forming a one-celled embryo, two major processes begin and progress simultaneously. The sperm head transforms into the male set of chromosomes, and the egg chromosomes resume and complete their second meiotic division. During the first process, the earliest visible change in the sperm head is swelling. The hereditary material of the spermatozoon, which has been very tightly coiled in the sperm head, is now looser and begins to look less dense. Concurrently, the sperm somehow activates the female chromosomes, which start to separate into two groups. As the sperm head continues to swell, finally developing into the male pronucleus (the collected male-derived chromosomes), the two groups of egg chromosomes separate widely. Finally, one group is pinched off in a bit of protoplasm; although this second polar body degenerates and fragments more slowly, it eventually suffers the same fate as the first. By forming the second polar body, the human egg has at last reduced its chromosome number to 23, or half the normal human number of 46. These 23 chromosomes then form the female pronucleus.

The male and female pronuclei, progenitors of a two-celled embryo, gradually approach each other. At this early stage, the individual chromosomes are metabolically very active, synthesizing new nucleic acids. In preparation for the first embryonic cell division, the 23 male-derived and 23 female-derived chromosomes are replicating themselves. The two groups of chromosomes continue their centripetal

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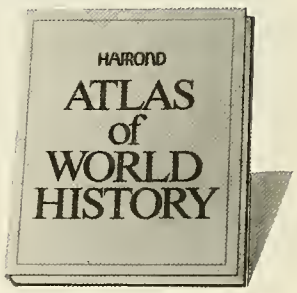
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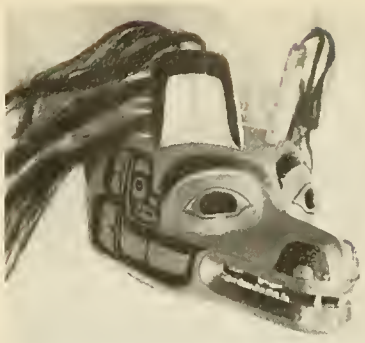
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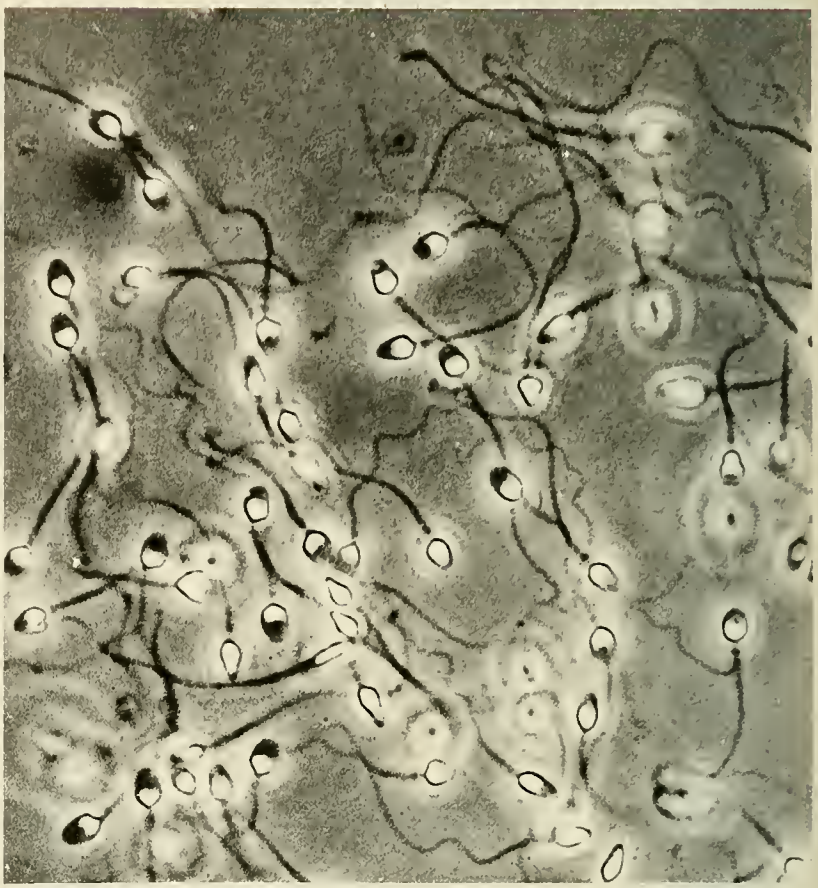
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Human spermatozoa (1,500X)

fective because of fertilization errors. Basically, fertilization errors consist of faulty chromosomal movements, so that the embryo contains an abnormal number of chromosomes, either too many or too few. Because chromosomes are linear aggregations of genes, a new organism with an inappropriate number of chromosomes has an excess or a deficiency of genes. Since the genes of a developing embryo signal to its organs when and how to form, a genetic imbalance means that the developing embryo will be subjected to abnormal genetic developmental signals, leading to malformation or to death and subsequent abortion.

Although the ultimate causes of chromosomal errors about the time of fertilization are not at all clear, we can describe what happens. Sometimes, the penetrating sperm head fails to activate the egg chromosomes to complete the second meiotic division. Then the embryo contains only one pronucleus with one set of functioning chromosomes. This condition is called androgenesis. The reverse situation, where the spermatozoon does activate the female-derived chromosomes, but then fails to swell and undergo pronuclear development, is termed gynogenesis. Cells that contain only one set of chromosomes, either male or female, are called haploid.

Both androgenesis and gynogenesis are lethal states. When half the genes are missing, little embryonic development is possible, and the individual usually succumbs before completion of more than a few cell divisions. No androgenetic or gynogenetic mammals have been found born alive.

Like too few sets of chromosomes, too many are also deleterious. Embryos may come to contain three, rather than two, sets and this state is called triploidy. In

Please turn to page 18

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some cases, triploidy can be traced to faulty action on the sperm's part. Normal spermatozoa undergo two meiotic divisions and then contain a single set of 23 chromosomes at maturity. Should one of the divisions fail to take place in a developing sperm cell, it will end up with 46 chromosomes. Fertilization by this kind of sperm will produce a triploid embryo with two paternal sets of chromosomes and one maternal set. The same abnormality can also result from double penetration, when a second spermatozoon manages to enter the egg protoplasm before the cortical granules render the ovular surface impenetrable.

Triploidy can also originate in the egg. As in sperm maturation, either the first or the second meiotic division can fail, and the first or the second polar body will not form. The embryo would possess two maternal sets and one paternal set of chromosomes.

Generally speaking, an excess of genetic material is less disruptive to an embryo than a deficiency, and triploid organisms usually develop further than haploid individuals. Nevertheless, the ultimate fate of the vast majority of triploids is abortion, often by the third month of pregnancy, but sometimes later. Chromosome counts in aborted embryos have indicated that as many as one percent of all human conceptuses may be triploid. A very occasional human triploid embryo develops far enough to be born at term. But these severely malformed individuals are either stillborn or succumb within a few hours or days.

Another common type of chromosomal error at fertilization involves excess or deficiency of single chromosomes, so that the embryo contains either 47 or 45 chromosomes. This state is known as aneuploidy. It can arise in an egg or a sperm through an aberration of chromosomal movement at either the first or second meiotic division or the first embryonic cleavage. At all three stages, when the chromosomes line up preparatory to division, they arrange themselves so that the members of each chromosomal pair are directed toward opposite poles of the cell. At division, exactly half the chromosomes are included in each of the two new cells. Sometimes, how-

ever, the members of a particular chromosome pair fail to divide and therefore travel together to the same cell. This cell will then contain one chromosome too many, while the other cell will be shortchanged by one chromosome. Should such a reproductive cell eventually take part in fertilization, the embryo will also be chromosomally long or short.

The 46 chromosomes of a normal individual are made up of 23 pairs; one member of each pair is derived from the sperm and one from the egg. An aneuploid embryo with 47 chromosomes has 22 pairs and one triad; the extra chromosome is derived from the abnormal sperm or egg. Such embryos are called trisomic. The reverse aberration, monosomy, consists of the possession of 22 pairs of chromosomes and one singleton, for a total of 45. As is the case with triploidy and haploidy, deficiency is more deleterious than superabundance, and most monosomic embryos never develop far enough to permit clinical recognition of the pregnancy. They degenerate so early that the menstrual period is usually not even delayed. The exception is monosomy for the sex-determining chromosomes, which may result in either a recognized miscarriage or the live birth of a sterile female with short stature and a variety of physical defects. Most trisomic embryos develop as far as the second or third month of pregnancy before they are aborted. Nevertheless, trisomy for a few chromosomes is compatible with live birth and, in some cases, with prolonged postnatal survival. Most of these individuals suffer severe physical and mental defects. The most common trisomic condition is the well-known Down's syndrome, or Mongolism, caused by trisomy for chromosome number 21.

Some more exotic types of chromosomal errors can also occur at fertilization. Studies of mouse eggs undergoing meiosis have shown that a small number of eggs fail to split at the first division into a large egg and a small polar body. Instead, they divide into two equal-sized cells, each containing one set of maternal chromosomes. Human hermaphrodites have been discovered, roughly half of whose cells contain a male set of chromosomes and half a female set. Such persons may have originated in the double

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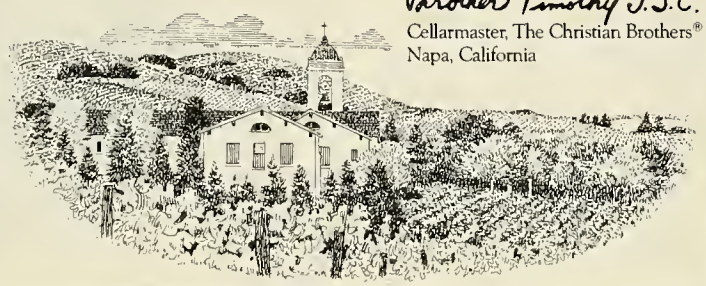
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fertilization of an egg and its giant polar body by an X-bearing sperm and a Y-bearing sperm.

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Longitudinal section of the head of a human spermatozoon (35,000X)



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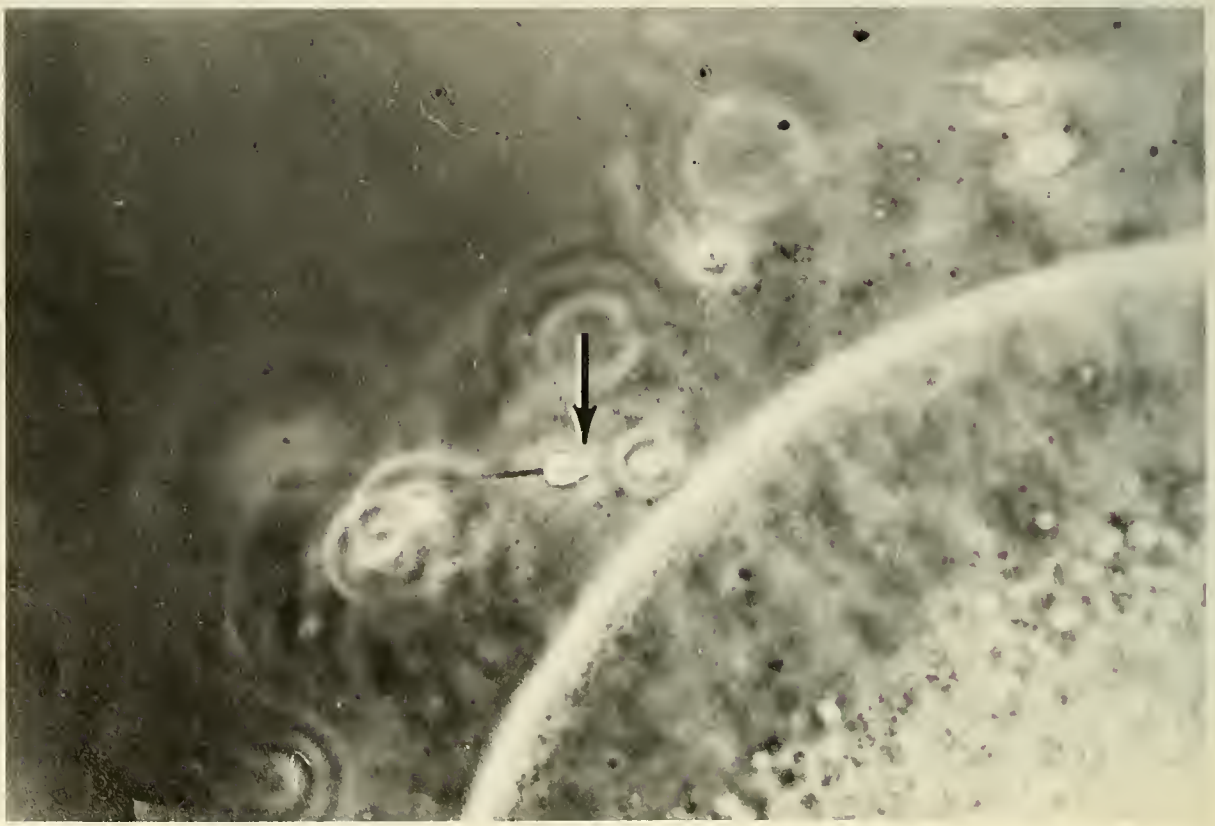
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have been sloughed off the fetus's body. After incubation in nutrient medium for about two weeks, the cells can be harvested and subjected to chromosomal analysis. The number of chromosomes per cell can be counted, and each individual chromosome can be identified. Amniocentesis should be considered by all pregnant women thirty-five years of age and older and by women who have previously borne a trisomic child. The chance of a repeat is 1 to 2 percent.

Although scientists know how to prevent abnormal births resulting from errors of fertilization, they still know very little about why and how mistakes happen. Researchers have been able to artificially accomplish the complicated natural process of fertilization, which can take place in laboratory vessels as well as in Fallopian tubes. In vitro (literally, "in glass") fertilization has been accomplished in several animal species, including humans. (At this writing scientists have just witnessed the birth in England of a healthy female, the first human to be conceived in vitro.) Meiosis and ovulation can be triggered and accurately timed by injections of gonadotropic hormones. Hence eggs can be recovered from the ovary via surgical procedures, just prior to the time at which ovulation would occur. The egg, which has gone through the first meiotic division, is placed in a plastic dish filled with nutrient culture medium. Then a suspension of sperm is pipetted into the dish, and for the next several hours, the mixture is maintained under strictly controlled conditions of atmosphere, temperature, and pH (alkaline-acid balance). Fertilization is presumed to have taken place when male and female pronuclei can be seen via the microscope. Many artificially fertilized eggs will divide and develop up to the point where implantation normally would occur. In some animal species, notably the mouse, these embryos have been placed into the uteri of hormonally prepared females, and some have implanted and been born alive as normal offspring.

Experiments with animals such as the mouse have shown that fertilization has not evolved in an orderly way at all. Presumably, the process would be simpler, in lower animals, with varying degrees of complexity in higher animals. But the process is equally complex in all mammals. Perhaps the information scientists now lack about the actual mechanics of fertilization will reveal more about the evolution of the process itself. □



A human spermatozoon, shown by arrow, passing through the zona pellucida of a human egg (1,950X).



Working wife

This picture and the following letter arrived unsolicited.

Dear Kodak:

Thank you for inventing Kodachrome 64 film. It saved my marriage.

For six years I had been trying to capture the enclosed photo in Colorado's Rocky Mountain National Park. Optimum lighting required shooting on a clear afternoon around June 21, when the sun is farthest north in the sky. I needed freshly-fallen snow for a contrasting background. I also needed a stiff wind blowing from the west so that, if a friendly large bird happened by, it could fly in the direction I desired. The wind would give the bird extra lift to fly fairly slowly. But too hard a gale would ground my feathered subjects.

With a 300 mm lens, I had to maintain significant depth of field while shooting at a speed fast enough to freeze the bird's motion. I insisted on Kodachrome film for its unbeatable color and absence of significant grain. But Kodachrome II film's ASA of 25 did not give me enough flexibility to combine all these requirements successfully, despite years of futile attempts.

After losing two previous models, I solved the problem of coaxing a model into this picture by marrying the prettiest rock climber I could find. But as years passed, Donna tired of ascending this rock. She could endure the bitter wind at 12,000 feet. But the fresh snow always melted to refreeze as a sheet of ice over her route up the cliff. And I pointed out that a protecting rope would spoil the photo's drama.

Finally, Donna delivered an ultimatum. She would climb the cliff once more. If I did not get my picture this time, I must choose: give up the photo or give up her.

I had been working on this photo for six years. I had been married only four. What choice would any dedicated photographer make?

But for the first time, I was using Kodachrome 64 film. The extra speed of this great film gave me the flexibility needed to capture at last a photo of the quality I had envisioned. Thank you, Kodak, for saving my marriage.

Sincerely,
Kent Dannen
Estes Park, Colorado

The lady, it now turns out, was helping bring in some income. We have purchased the right to use the picture to suggest to others the possibility of imaginative originality in family photography, even without getting that close to Long's Peak, the tallest in Rocky Mountain National Park. Two additional points:

1. Matching Mr. Dannen's enthusiasm for Kodachrome film, some other serious photographers are just as enthusiastic about Kodak Ektachrome 64, 200, and 400 films. The latter two provide even more speed and are less demanding in their processing requirements. You can even process them at home. Might be fun. Ask your dealer.

2. The bird is a Clark's nutcracker (*Nucifraga columbiana*). The species nests below treeline but obviously can be lured above it by memory of past rewards from an extended human arm. There's a second on the rock. See it?

Kodak

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by Raymond Sokolov

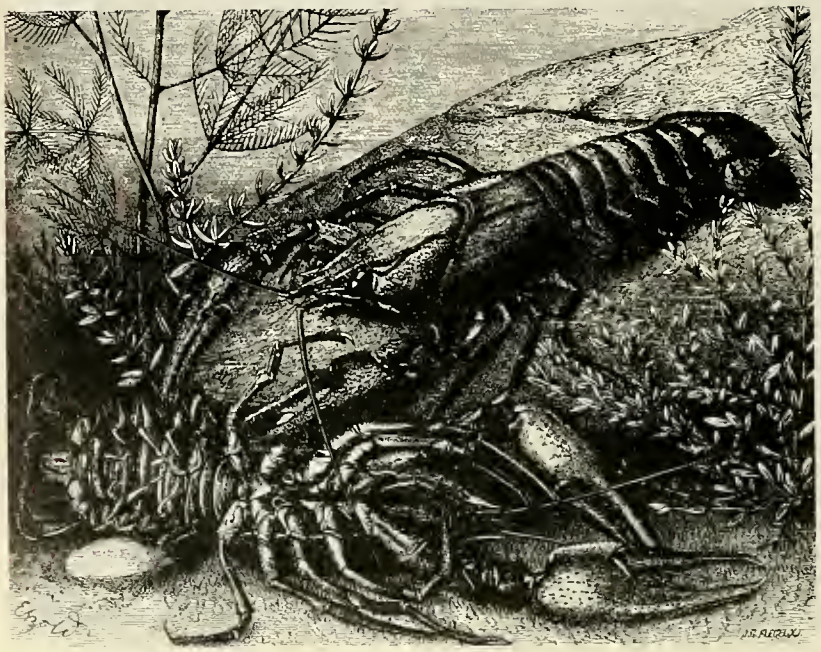
Shell Game

Crayfish, along with their lobster kin, are highly prized for their delicate flesh

Salivating in anticipation of what lay ahead, I recently entered a small restaurant on Manhattan's East Side, but as soon as I had had a moment to look around, I knew that something was radically wrong. The tank in the window was empty. A woebegone waitress explained wretchedly that last winter's severe weather had decimated the crayfish supply. This was, of course, primarily a tragedy for crayfish, but for the restaurant, which had just opened and was supposed to specialize almost entirely in dishes featuring the delicate and flavorful flesh of *Orconectes limosus*, it was also no picnic. For my part, the bad news was just one more ironic slap delivered by those malignant spirits who seem always to be snatching my favorite shellfish from my mouth.

The crawdad harpies see to it that I arrive in New Orleans or Lyon just as these elusive minilobsters go out of season. For some unknown reason, crayfish, which abound in many American rivers, are harvested almost exclusively in Louisiana, where crawfish (as they are locally known) are a major preoccupation of life between November and July. In New York, the crayfish lover must either haunt specialty shops or go through the contortions of mail ordering. There are other, more extreme alternatives: one can fly to Los Angeles for a very expensive snack of imported European crayfish (*Astacus astacus*) at the Scandia Restaurant or one can go fishing.

At any rate, I hope nearly everybody will, at some time or other, have a chance to taste or to cook crayfish, that is, if we do not have a repeat of last winter. Assuming normal weather and the continuation of a form of life that goes back in time to at least the Jurassic Period, we stand at the brink of gastronomic opportunity. We must prepare our minds for that day when crayfish swim into our ken by looking closely at what is known about them, as creatures and as food.



Zoologists classify crayfish among the arthropod invertebrates in the crustacean class, which means that they are distantly related to spiders and scorpions but more closely and obviously connected with such invertebrate, water-breathing, segmented animals—with hard outer carapaces and two antennae—as lobsters, shrimps, and crabs. These large, edible crustaceans are grouped in the order Decapoda because they have five pairs of appendages arrayed on either side of the thorax (the middle segment, between the head and tail). Sometimes the pair closest to the head develop into claws, or pincers, called chelae. There are some 8,500 species of decapods, which makes them as various in their evolutionary adaptation as birds.

Despite all this diversity, decapods are similar enough for the commonly eaten varieties to be frequently confused with each other. Their vernacular names are a tangled web of etymologically related terms that usually predate scientific observation. The word *crayfish*, for example, is the English reflex of the French *écrevisse*, which in turn derives from an ancestral term that appears in Old High German as *krebiz*, or "crab." *Crawfish* is not only an American regional form of *crayfish* but is also applied to the so-called spiny lobsters (family Palinuridae), which lack large claws, have antennae longer than their bodies, exhibit spiny processes on the carapace, and are also known as sea crayfish (although they may grow almost twice as long as the European crayfish's maximum of ten inches) and langoustes. *Langouste* derives from the Latin *locusta*, which the Romans applied both to locusts and lobsters. *Lobster* itself also descends from *locusta*, a confusion

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that is easy to understand, just as it is not too hard to see why the deepwater *langoustine*, or *langostino (Nephrops norvegicus)*, which has pincers, but grows smaller in body size than the langouste, is also known as the king, or Norway, lobster.

For the gastronome, these overlapping misnomers actually make a certain amount of common sense, since, to the taste buds, there is a general family relationship between the highly prized muscle tissue of the claws and tails (abdomens) of all the edible decapods. They taste different, of course, but their overall similarity makes it perfectly feasible to interchange one decapod with another in recipes. If the cook pays attention to obvious variations in cooking times required for, say, crayfish and lobsters, it is not only possible but traditional to prepare them in conceptually identical ways —in bisques, boiled, and so on. (In many cases, crabs and shrimps can also be substituted for their fellow crustaceans.)

Nevertheless, I feel sure that in a blind tasting I could distinguish the meat of these kindred arthropods from slight differences in texture, size, flavor, and grain. But I doubt that, their different lengths aside, I or anyone else could tell apart, by palate alone, the short (maximum five inch) American crayfish from its European cousin. Ecologically, however, the two species are crucially distinct. The European crayfish is extremely sensitive to pollution, requires very clean water, feeds at night on plant and animal material, and otherwise hides in holes in river banks. The American crayfish is much hardier, can withstand dirty water, feeds round the clock, and does not burrow. Most important of all, the American crayfish is immune to crab plague, the fungus that nearly extirpated *Astacus astacus* starting in 1870 and continues to infect the effete Old World decapod to this day. *Orconectes limosus* was successfully introduced into European rivers in 1890 and still flourishes.

Even if someone could convince me that one type was superior to the other, I would still be delighted to come by a supply of either kind. I would not mind the tedium of shelling several dozen little tails. I would happily pull apart fifty to a hundred young crayfish to produce

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a cup of meat. And with machines that do the job of mortar and pestle, I don't need prepicked crayfish fat (a convenience food extracted from the heads in Louisiana and sold frozen as a substitute for pounded shells in making sauces) to coax me into cooking crayfish.

I do know one shortcut that I will be glad to use. It avoids the traditional method of removing the crayfish's tiny, filthy gut. Old French recipes insist that you pull out, "castrate," this offending organ with a knife, just before cooking and while the crustacean is still alive. Today, the French chefs Paul Bocuse and Michel Guérard put crayfish in skim milk for twelve hours before cooking them, and the crayfish purge themselves. If the tails are eventually served shelled, it is easy to remove the guts by pinching them between thumb and forefinger and pulling them out starting at the top, or head end, of the tail.

Otherwise, crayfish cuisine comes down to two basic techniques that resemble the two fundamental approaches to lobster. You can plunge crayfish into boiling water or you can sauté them.

Boiling can be utterly simple. The water need only be salted. But the two leading crayfish regions, France and New Orleans, have developed their own, more sophisticated flavoring methods. The French method, called *à la nage* ("swimming"), uses a court bouillon: a cooked broth of vegetables, seasonings, and wine (see recipe below). New Orleans follows more or less the same procedure, but the court bouillon is much spicier and does not involve wine. Standard cooking times in both versions are ten to twelve minutes. Overcooking toughens the flesh. But letting the finished crayfish "relax" for a few minutes at room temperature tenderizes it still further.

Boiled crayfish lend themselves to many other uses, such as garnishes for other dishes or served cold *en buisson*, which is to say, impaled by their tails on a special tiered metal device that when fully loaded with crayfish looks like a pink, dodecapodal bush.

Sautéing crayfish can be more cumbersome than boiling. It also forces you to fry a living crustacean, but at least you do not have to slice the crayfish crosswise

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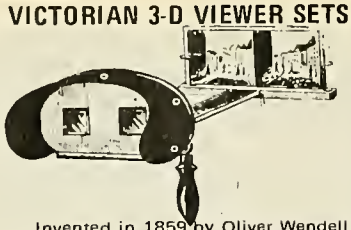
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beforehand the way you must slice a lobster before sautéing it. Crayfish are smaller and go into the pan whole. The end, at any rate, comes quickly, and who is to say that crayfish bordelaise (sautéed with finely chopped vegetables in butter, then flamed in white wine and cognac) is not a more noble end for a crayfish than twenty years of skulking in riparian burrows or scuttling along polluted stream bottoms until it dies of natural causes?

Sautéed crayfish can also be sublimated into crayfish Nantua by reserving the tail meat and using the shells and other debris to make a brilliant red-orange sauce (pulverize shells and debris, force through a fine strainer, and combine with béchamel).

New Orleans fills crêpes with sautéed crayfish or stuffs crayfish shells with chopped, sautéed meat or bakes it in a pie. France, typically, puts crayfish into mousses and soufflés, compound butters, and bisques.

The latest wrinkle in French crayfish cookery comes from the genius of the "new cuisine," Michel Guérard, and it is so complex it will make you smile at the *nouvelle cuisine*'s claims of simplicity. Basically, Guérard takes cooked crayfish tails and wraps them inside very thin slices of bass so as to make tiny bundles, which are then briefly baked in a tomato-crayfish sauce and served surrounded by a floral pattern made with blanched leaves of Brussels sprouts. You would hardly think that such an exquisitely refined dish began as a ten-legged creature foraging in a turbid creek.

Crayfish (or Lobster) à la Nage, Michel Guérard

2 medium carrots, scraped and cut in thin rounds
1 leek, only the white part, cut in thin rounds
1 celery rib, sliced crosswise
4 small white onions, peeled and sliced
2 shallots, peeled and sliced
5 cups water
2 tablespoons kosher salt
5 lemon peels
2 unpeeled garlic cloves
25 green peppercorns
1 whole clove
A bouquet garni—6 parsley sprigs, ½ bay leaf, 1 small fresh fennel stalk, and 1 sprig of thyme tied together
1 cup dry white wine
20 crayfish weighing about 2 ounces each (or 1 live 2-pound lobster)
1 tablespoon freshly chopped parsley

1. Put the carrot, leek, celery, onion, and shallot slices in a large stainless steel pot. Add the water, salt, lemon peels, cloves, green peppercorns, whole clove, and bouquet garni.
2. Bring to a boil, reduce heat, and simmer uncovered, very gently so that the water merely shudders, for 30 minutes. The vegetables should remain a bit firm.
3. Pour in the white wine, boil for 30 seconds. Discard the bouquet garni. Let cool and reserve until you are ready to cook the shellfish. (This court bouillon can be stored in the refrigerator and reused several times for boiling shellfish, so long as you reboil it every few days.)
4. When you are ready to prepare the shellfish, bring the court bouillon to a boil, uncovered.
5. If you are using lobster, crack the claws with the back of a heavy knife to facilitate removing the meat after cooking.
6. Plunge the crayfish (or lobster) into the boiling court bouillon. The crayfish will be done in 2 minutes. The lobster will take 14. (Guérard believes in slightly undercooking crayfish and lobsters. Make sure yours are at room temperature if you follow these directions. Conventional times would be 10 to 12 minutes for crayfish, 20 for the lobster.)
7. Drain the crayfish and pile them in a bowl. Sprinkle with parsley. Or split the lobster lengthwise with a large knife. Remove the claws and take the meat out of the shell. Remove the intestinal pouch from the lobster's head and discard. Arrange the lobster pieces on a serving platter. Cover them with vegetables from the court bouillon. Moisten with a cup of cooking liquid. Sprinkle with parsley.

Yield: Two servings

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.

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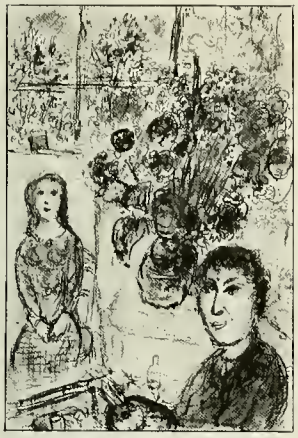
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ONE OF THESE CAMERAS WAS MADE JUST FOR YOU. HERE'S HOW TO TELL WHICH ONE.

If you've considered buying a 35mm single lens reflex camera, you may have wondered how to find the right one out of the bewildering array of models and features available.

And you have good reason to wonder, since the camera you choose will have a lot to do with how creative and rewarding your photography will be.

Of course, what you pay for your camera is important. But it shouldn't be your only consideration, especially since there are very expensive cameras that won't give you some of the features you really need. So before you think about price, ask yourself how you'll be using the camera and what kind of pictures you'll be taking. Your answers could save a lot of money.

How automatic should your camera be?

Basically, there are two kinds of automatic 35mm SLR's. Both make use of advanced electronics to give you perfectly exposed pictures with point, focus and shoot simplicity. The difference is in the kind of creative control you get.

For landscapes, still lifes, portraits and the like, you'll want an *aperture-priority* camera. It lets *you* set the lens opening, while *it* sets the shutter speed automatically.

This way, you control depth-of-field. That's the area of sharpness in front of and behind your subject. Many professional photographers believe that depth-of-field is the single most important factor in creative photography.

At times you may want to control the motion of your subject for creative effect. You can do this with an aperture-priority camera by changing the lens opening until the camera sets the shutter speed necessary to freeze or blur a moving subject. Or you can use a *shutter-priority* camera, on which you set the shutter speed first and the camera sets the lens opening automatically.

Minolta makes both types of automatic camera. The Minolta XG-7 is moderately priced and offers aperture-priority automation, plus fully manual control. The Minolta XD-11 is somewhat more expensive, but it offers both aperture and shutter-priority automation, plus full manual. The XD-11 is so advanced that during shutter-priority operation it will actually make exposure corrections you fail to make.



Minolta makes all kinds of 35mm SLR's, so our main concern is that you get exactly the right camera for your needs. Whether that means the advanced Minolta XD-11. Or the easy-to-use and moderately priced Minolta XG-7. Or the very economical Minolta SR-T cameras.

Do you really need an automatic camera?

Without a doubt, automation makes fine photography easier. But if you're willing to do some of the work yourself, you can save a lot of money and get pictures that are every bit as good.

In this case, you might consider a Minolta SR-T. These are semi-automatic cameras. They have built-in, through-the-lens metering systems that tell you exactly how to set the lens and shutter for perfect exposure. You just align two indicators in the viewfinder.

What should you expect when you look into the camera's viewfinder?

The finder should, of course, give you a clear, bright view of



Automatic sequence photography is easy when you combine a Minolta XD-11 or XG-7 with optional Auto Winder and Electroflash 200X.

Specifications subject to change without notice

your subject. Not just in the center, but even along the edges and in the corners. All Minolta SLR's have bright viewfinders, so that composing and focusing are effortless, even in dim light. And with a Minolta there's never a question about focusing. You'll find focusing aids in every Minolta 35mm SLR viewfinder that make it easy to take critically sharp pictures.

Information is another thing you can expect to find in a well-designed viewfinder. Minolta believes that you should never have to look away from the finder in order to make camera adjustments. So everything you need to know for a perfect picture is right there in a Minolta finder.



The match-needle viewfinder: just align two indicators for correct exposure. Because you're doing some of the work, you can save some money.



The electronic viewfinder: light emitting diodes tell you what the camera is doing automatically to give you correct exposure.

In the Minolta XD-11 and XG-7, red light emitting diodes tell you what lens opening or shutter speed is being set automatically and warn against under or over-exposure. In Minolta SR-T cameras, there are two pointers which come together as you adjust the lens and shutter for correct exposure.

Do you need an auto winder?

If you like the idea of sequence photography, or simply want the luxury of power assisted film advancing, an auto winder may be for you. Minolta auto winders will advance one picture at a time, or continuously at about two pictures per second. And they give you advantages not found in others, like up to 50% more pictures with a set of batteries and easy attachment to the camera without removing any caps. Optional auto winders are available for both the Minolta XD-11 and XG-7, but not for Minolta SR-T cameras.

How about electronic flash?

An automatic electronic flash can be combined with any Minolta SLR for easy, just about foolproof indoor photography without the bother of flashbulbs. For the XD-11 and XG-7, Minolta makes the Auto Electroflash 200X. It sets itself automatically for correct flash exposure, and it sets the camera automatically for use with flash. An LED in the viewfinder tells when the 200X is ready to fire. Most unusual: the Auto Electroflash 200X can fire continuously in perfect synchronization with Minolta auto winders. Imagine being able to take a sequence of 36 flash pictures without ever taking your finger off the button.

You should be comfortable with your camera.

The way a camera feels in your hands and responds to your commands can make a big difference in the way you take pictures.

The Minolta XD-11 and XG-7, for instance, are compact, but not cramped. Lightweight, but with a solid feeling of quality. Controls are oversized and positioned so that your fingers fall naturally into place. And the electronically controlled shutters in these advanced automatic cameras are incredibly smooth and quiet.

Minolta SR-T's give you the heft and weight of a slightly larger camera, but with no sacrifice in handling convenience. As in all Minolta SLR's, "human engineering" insures smooth, effortless operation.

Are extra features important?

If you're going to use them, there are a lot of extras that can make your photography more creative and convenient. Depending on the Minolta model you choose, you can select from a number of special features. For instance, some models let you take multiple exposures with pushbutton ease (even with an auto winder). Other available extras include a window to show that film is advancing properly, a handy memo holder that holds the end of a film box to remind you of what film you're using, and a self-timer that delays the release of the shutter so you can get into your own pictures.

What about the lens system?

Just about every 35mm SLR has a lens "system." But it's important to know what the system contains. It should be big enough to satisfy your needs, not only today, but five years from today.

There are almost 40 interchangeable lenses available for Minolta SLR's, ranging from 7.5mm fisheye to 1600mm super-telephoto, including macro and zoom lenses and the smallest 500mm lens in the world. And since interchangeable lenses should be easy to change, the patented Minolta bayonet mount lets you remove or attach them with less than a quarter turn.

What's next?

After you've thought about how you'll be using your camera, ask your photo dealer to let you try a Minolta. Handle the camera for yourself. Examine its features and the way Minolta has paid close attention to even the smallest details. And by all means, compare it with other cameras in its price range. You'll soon see why more Americans buy Minolta than any other brand of SLR. For literature, write Minolta Corporation, 101 Williams Dr., Ramsey, N.J. 07446.

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The Politics of Black Power Handshakes

by John Baugh

Deciding when to use this in-group grasp may be more complicated than performing the grasp itself

The scene is a public swimming pool in a black working-class neighborhood in Los Angeles, on the opening day of the summer season. The staff members, some black from the local community and some white from other communities, are making and reestablishing acquaintances. In a typical reunion, two black staff members greet each other with this dialogue:

Howard: "Hey babe, what's happening? It's been a while."

Douglas: "Well, you know how it is. Always slow and not enough dough."

Howard: "I heard that."

While they talk, Howard and Douglas use the black power handshake, which, in this neighborhood, consists of three separate grasps executed in rapid order.

A white staff member, Dave, then approaches. He lives outside the local community, and neither Howard nor Douglas knows him. They greet him with some hesitation:

Dave: "Hi, I'm Dave."

Howard: "How you feeling, my man? I'm Howard—and—and this here is Douglas."

Douglas (nodding toward Dave in recognition): "What's happening?"

Dave: "Not much. Tell me, have you guys ever worked here before?"

Dave offers his hand to Howard for a black power handshake, with his forearm vertical. But Howard raises his arm, with the forearm horizontal, and grasps Dave's hand in the traditional, standard handshake. When they release hands, Dave offers his hand to Douglas at hip level for the standard handshake, which Douglas returns quite naturally.

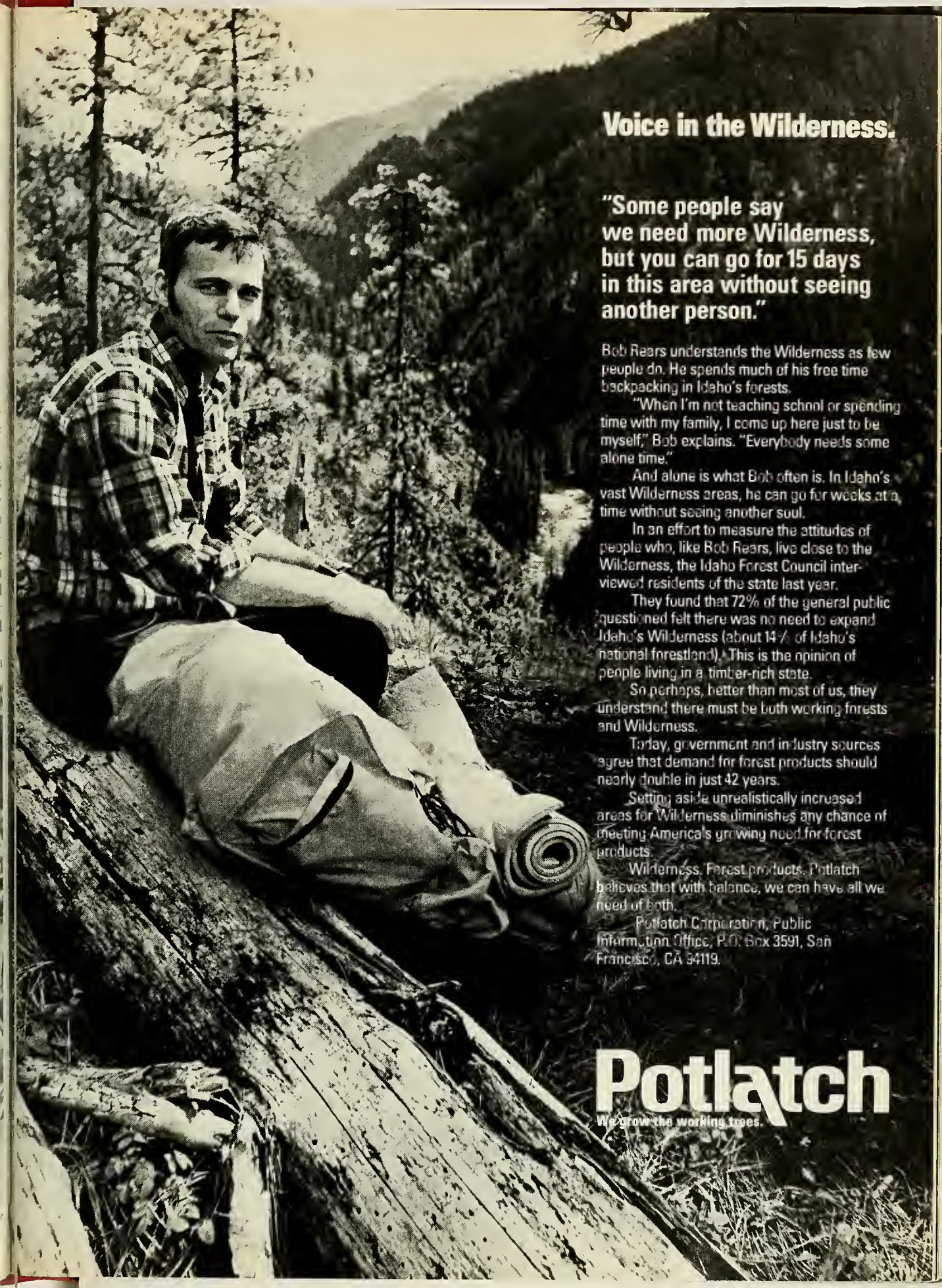
In American society, as well as throughout many of the world's cultures, the handshake is a display of solidarity and ritualized access in most everyday, face-to-face encounters. A handshake takes place after two people acknowledge each other, move close together, and execute a series of verbal and/or gestural cues. Either individual may initiate the handshake.

Like spoken or sign language, a



Lester Sloan

Several types of nonstandard handshakes are exchanged in this gathering in a Los Angeles park.



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In an effort to measure the attitudes of people who, like Bob Rears, live close to the Wilderness, the Idaho Forest Council interviewed residents of the state last year.

They found that 72% of the general public questioned felt there was no need to expand Idaho's Wilderness (about 14% of Idaho's national forestland). This is the opinion of people living in a timber-rich state.

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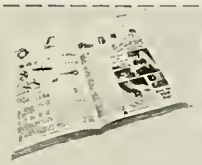
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handshake has a meaning transmitted in a clear, defined way, with its own "grammatical" structure. Hand-to-eye gestures, in which one person sees and interprets the offer of a hand by another person, can be articulated and decoded in much the same way as mouth-to-ear utterances. And just as conversation requires knowledge of a common language, handshakes require knowledge of shared norms.

Recently, many black Americans have developed and used elaborate new handshakes that demonstrate solidarity under special circumstances. The use of exclusionary handshakes is by no means a radical or new phenomenon. Fraternal organizations have often devised in-group handshakes, some of which are secret. What makes the black power handshake so interesting is that its use has extended well beyond a small group to the point of being politicized.

This handshake is used continually in public by many blacks, and it has been exposed through the mass media and spectator sports to whites who have had little contact with Afro-Americans. Some whites use the black power handshake in their more intimate circles as a symbol of group cohesiveness.

More difficult than performing an elaborate in-group handshake is knowing when to use it. This decision can place special demands on the participants. At the pool, two old friends, the blacks Howard and Douglas, used the black power handshake as a public display of solidarity and intimacy. But when they met Dave, in a situation in which the criteria of familiarity and racial homogeneity were not met, they used the standard handshake.

During a four-year period, I observed and analyzed more than six hundred handshakes performed at the Los Angeles municipal pool where Howard, Douglas, and Dave worked. (These names are pseudonyms.) At least one participant in each handshake was a resident of the local black community. The exchanges cited earlier were typical of the patterns that developed. In general, insiders greeted each other with the black power handshake and they greeted outsiders with the standard handshake. Yet the decision was not always that cut and dried. Sometimes, deciding which handshake to use demanded quick judgment. For people who actively employed more than one handshake style, each occurrence of this social ritual required a definition of the situation—a decision about which norm satisfied the immediate social requirements.

The use of handshakes between two antagonists, formerly friends, illustrates how involved this decision may be. Richie and TJ, considered to be friendly, had been assigned to seats at the same table at a wedding reception. Yet they were no longer friends. Richie had been dating Diane, but Diane became interested in TJ, whom she began to date on the sly. As is often the case, Richie was one of the last to know about Diane's change of heart. He lost face and subsequently became the subject of mild ridicule. To complicate matters, rivalry between Richie and TJ was not new, since they had been on the same football and track teams in high school. Diane eventually broke off with Richie and began to talk openly about the possibility of marrying TJ.



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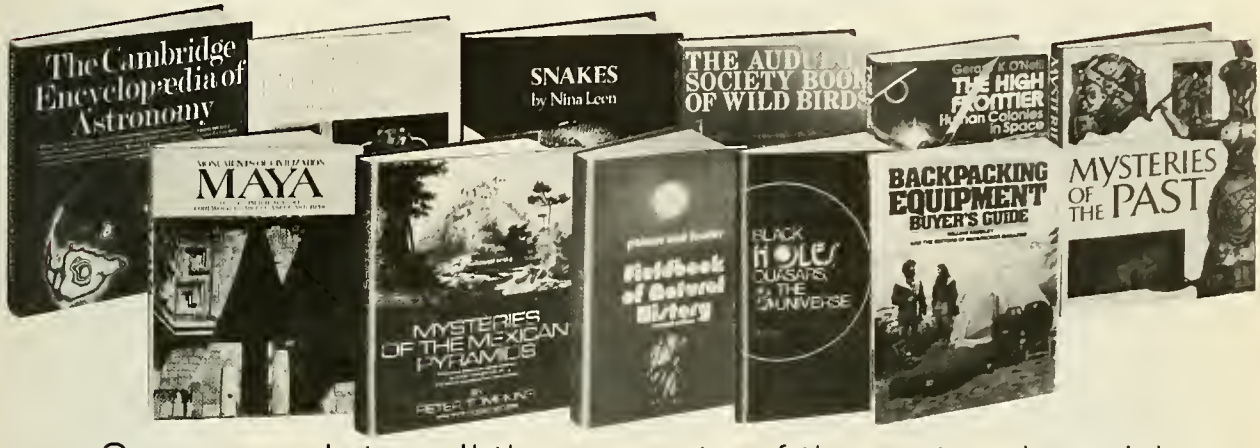
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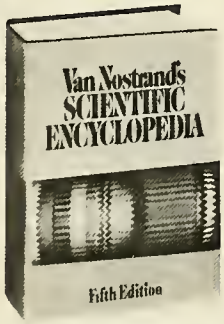
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Eight young black adults, including Richie and TJ, gathered around the table at the wedding reception. All five men, with the exception of the two rivals, exchanged the black power handshake when they greeted each other. When Richie and TJ used the standard handshake with hesitation, and when their smiles turned to solemn, penetrating glances, the other guests became alerted to the antagonism. In the context of the social situation, in which use of the black power handshake was common, exchange of the standard handshake by two persons assumed to be friends indicated that something had gone awry in their relationship. This changing of norms might be the equivalent of one man refusing to shake hands with another man in a white, middle-class gathering.

The two examples I have provided illustrate how a choice of handshakes is made in meetings between friends, strangers, and enemies. But what does use of the black power handshake mean in more complex situations involving blacks and whites? Once just an expression of solidarity within black cliques, the black power handshake now serves a much broader population as well. Its use in different situations by white and black staff members at the pool reflects the politicization of the black power handshake and its effect on interracial relations.

Carl was a 22-year-old white lifeguard from outside the community and was fairly well-to-do compared with most of the local blacks. Ronald was a 28-year-old black community aide at the pool. Until recently unemployed, Ronald acted as a mediator between the black users of the pool and the staff of predominantly white lifeguards. Although his job required considerably more physical work than was demanded of a lifeguard, Ronald's salary was much lower than Carl's.

Carl had contacts with people who could provide audio equipment at exceptionally low prices. After news of this "connection" spread by word-of-mouth, some of the young black men in the local community reluctantly began to approach him about arranging for purchases. At first, Carl appeared not to be interested since he did not want his access to stolen stereo equipment widely publicized, but when Ronald offered to serve as a middleman, Carl agreed. The first test of the arrangement came when Ronald asked for a car stereo for his own use. Expecting used equipment, Ronald was delighted when Carl delivered a brand new unit. Ronald offered the black power handshake to Carl and said, "We got the making of a real good thing here." Carl smiled and nodded in agreement as they shook hands. Ronald then began to distribute the equipment, upping the price so he made a modest profit.

Ronald continued to use the black power handshake when he greeted Carl, once in front of two other black men from the local community who were also interested in the audio equipment. Each of Ronald's friends initiated the black power handshake when they met Carl, presumably as a gesture of good will. Sometimes Ronald invited Carl to stop by his house after work, and Carl accepted at least twice. In all, I observed the two exchanging black power handshakes eight times, generally at a sale of stereo equipment.

From Ronald's point of view, these handshakes helped to maintain good will in the business relationship. Carl, however, could easily have interpreted these gestures of good will as signs of personal friendship. As it turned out, conflicts arose because of Carl's misinterpretation of his relationship with Ronald.

One day, Ronald and two of Carl's black customers were lounging with some friends in the shade of a tree on a patch of grass near the pool parking lot, "sipping wine and killing time." Carl nonchalantly approached and asked for a glass of wine. In the group were several men who did not know Carl at all, including one man who recently had been released from county jail, where racial boundaries are never crossed. These men simply did not acknowledge Carl's presence. Ronald and the other customers snubbed Carl as well. Carl then confronted Ronald directly and asked, "What's happening?" The blacks remained silent. Carl then said, "Hey, Ronald, what's happening?"

Ronald (in a monotone): "Ain't nothing happening."

Carl (turning to another acquaint-

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ance named D): "Is it okay if I have a sip of your wine?"

D (hesitating): "Well uh, uh, Y'see—t'tell—t'tell you the truth, I really don't know—[raising his voice and smiling] besides—it just ain't sanitary and shit to go drinking behind people, specially when you don't know where they been putting their mouths."

The group laughed while they poured wine for each other.

Ronald: "Naw, man—it don't look like we got enough to go round—You know how it is with poor folks, you got to sip it slow and make it last."

The group continued to laugh while Carl, eyes downward, turned and walked away. Carl no doubt felt betrayed. In his relationship with Ronald and the other two customers, he had never before encountered the apparent hostility that the group had just directed at him.

From that point forward, Ronald ignored Carl, which only accentuated the difficulties caused by Carl's misplaced familiarity, and which probably added to Carl's sense of being betrayed. Carl's unhappiness carried over into work. Eventually, the pool manager called the two in to discuss their bad feeling and the detrimental impact the conflict was having on the other workers. Both men denied that any such problem existed.

Ronald: "Naw, man, me and Carl is *tight*, ain't we?"

Carl: "Yeah, we've been friends all summer long. I don't know where you got the idea something was wrong."

Boss: "I got it from the way you two have been acting. Listen, if you're friends or enemies makes no difference to me, but if you're on this job, I don't want to see or feel any tension."

Ronald: "No way, we've been getting along good."

Carl: "Yeah, right."

Ronald rose from his chair and walked over to shake hands with Carl—using the standard handshake.

Boss: "Okay, then, but I don't expect this staff to fall apart. When you're on the job, you work together, because if you can't we'll have to consider some unpleasant alternatives."

Ronald: "You don't got a thing to worry about."

Boss: "Oh, I'm not worried. You can believe that."

The boss turned to his paper work and Ronald and Carl left.

Here, Ronald used the standard handshake for much the same reason that Richie and TJ used it at the wedding reception: the gesture was made in appeasement, to defuse the situation. However, the handshake did not end the misunderstanding. Tensions continued between the two men, and the audio equipment transactions ended.

Although every handshake has its own individuality, owing to the great variety of people greeting each other in many different social situations, there appear to be common forces working on people who have a choice of handshakes to use. Exchange of the black power handshake demonstrates an especially strong personal or circumstantial bond both to the participants themselves and to any observers. Use of the more common standard handshake does not signify such a strong relationship, and the standard handshake is used much less selectively than is the black power handshake.

Allegiance to a group may be confirmed or denied by the use or disuse of a particular handshake, as Carl's experience indicates. Once nonmembers start to use a special handshake, however, the grip loses its potency as a symbol. This is why the politicization of the black power handshake, which has spread well beyond the Afro-American community, has led to the invention of increasingly expressive and even more elaborate handshakes. In many ways, the development of handshakes is similar to the use of slang words, which, as social situations change, are invented, disseminated, dropped from the vernacular, and then rediscovered.

Since few other human rituals provide such highly articulated and observable mutual behavior, the study of handshakes might help us to identify ongoing changes in the norms of various cultures. The existing evidence suggests that handshakes serve important functions in American society. In the community that I studied, the choice of handshakes symbolized and directly affected personal relationships of at least seven people. The indirect effect was probably much greater. □

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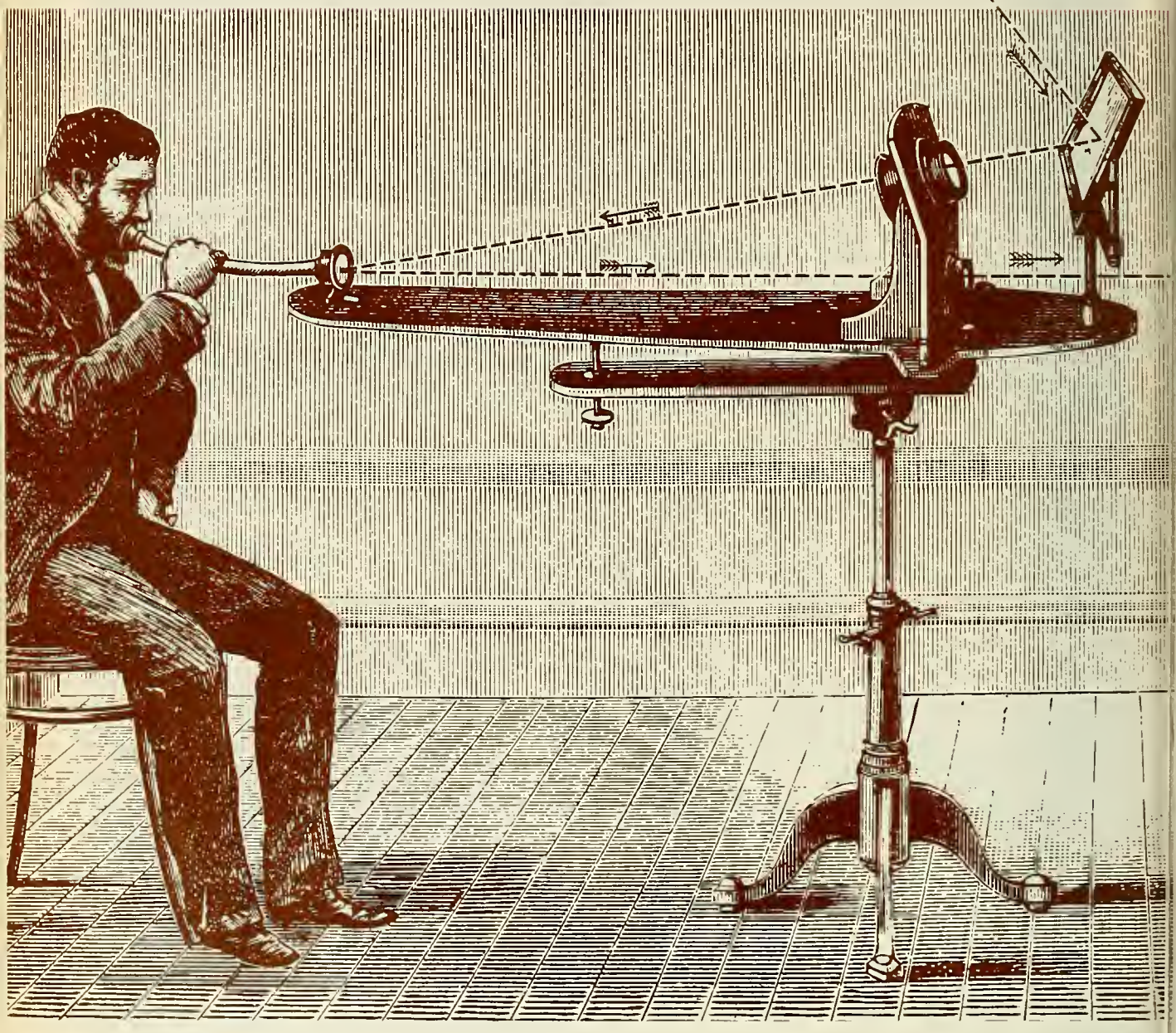
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Sunbeams are scattered by air, rain and fog. In any event, the sun doesn't always shine. The Photophone, unfortunately, was an idea whose time had not yet come.

A new kind of light

By the 1950's, scientists again were looking for a way to use light for communications.

In September, 1957, Charles Townes, a Bell Labs consultant, and Bell Labs scientist Arthur Schawlow conceived a way of producing a new kind of light—extremely intense, highly directional, and capable of carrying immense amounts of information.

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Since then, Bell Labs scientists have invented hundreds of lasers, including many firsts—gas and solid-state lasers capable of continuous operation, high-power carbon dioxide lasers, liquid dye lasers that produce pulses shorter than a trillionth of a second, and tiny semiconductor lasers that work reliably at normal temperatures. Some of these, no larger than grains of salt, may emit light continuously for 100 years.

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Spin-off

Laser light is now used in many other ways—to perform delicate eye surgery, detect air pollution, read product codes at supermarket checkouts, and do a variety of manufacturing tasks. Western Electric, the Bell System's manufacturing and supply unit, was the first company to put the laser to industrial use back in 1965. Hundreds of applications in many industries have followed.

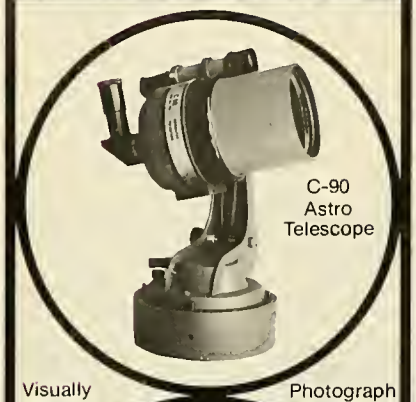
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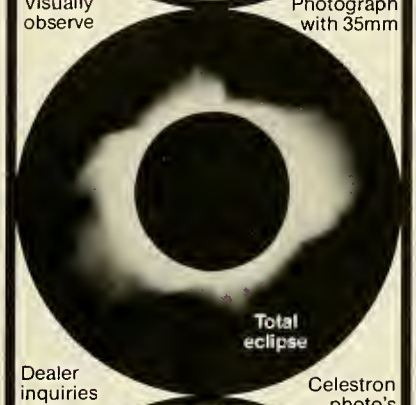
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Women's Brains

Biological measurements of intelligence are "irrelevant and highly injurious"

In the prelude to *Middlemarch*, George Eliot lamented the unfulfilled lives of talented women:

> Some have felt that these blundering lives are due to the inconvenient indefiniteness with which the Supreme Power has fashioned the natures of women: if there were one level of feminine incompetence as strict as the ability to count three and no more, the social lot of women might be treated with scientific certitude.

Eliot goes on to discount the idea of innate limitation, but while she wrote in 1872, the leaders of European anthropometry were trying to measure "with scientific certitude" the inferiority of women. Anthropometry, or measurement of the human body, is not so fashionable a field these days, but it dominated the human sciences for much of the nineteenth century and remained popular until intelligence testing replaced skull measurement as a favored device for making invidious comparisons among races, classes, and sexes. Craniometry, or measurement of the skull, commanded the most attention and respect. Its unquestioned leader, Paul Broca (1824–80), professor of clinical surgery at the Faculty of Medicine in Paris, gathered a school of disciples and imitators around himself. Their work, so meticulous and apparently irrefutable, exerted great influence and gained a high reputation as a jewel of nineteenth-century science.

In 1861, an epochal debate extended over several meetings of the Anthropological Society of Paris, founded two years earlier by Broca. Louis Pierre Gratiolet read a paper denying that brain size played a measurable role in establishing degrees of intelligence among humans. (Gratiolet, a royalist, was no egalitarian. He merely sought other measures for the inferiority of blacks and women—earlier closing of the skull sutures, for example.) Broca and his disciples attacked and routed poor Gratiolet. Brain size had its limitations and exceptions, but it served as a good general index of intelligence. And guess who, in Broca's words, won out?

> In general, the brain is larger in mature adults than in the elderly, in men than in women, in eminent men than in men of mediocre talent, in superior races than in inferior races. . . . Other things equal, there is a remarkable relationship between the development of intelligence and the volume of the brain.

Broca's work seemed particularly invulnerable to refutation. Had he not measured with the most scrupulous care and accuracy? (Indeed, he had. I have the greatest respect for Broca's meticulous procedure. His numbers are sound. But science is an inferential exercise, not a catalog of facts. Numbers, by themselves, specify nothing. All depends upon what you do with them.) Broca depicted himself as an apostle of objectivity, a man who bowed before facts and cast aside superstition and sentimentality. He declared that "there is no faith, however respectable, no interest, however legitimate, which must not accommodate itself to the progress of human knowledge and bend before truth." Women, like it or not, had smaller brains than men and could not equal them in intelli-

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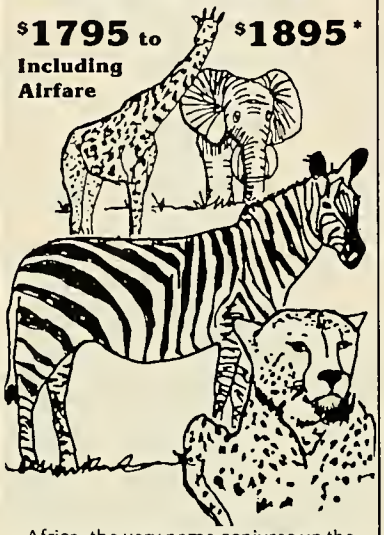
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gence. This may reinforce a common prejudice in male society, but it is also a scientific truth. L. Manouvrier, the one member of Broca's school who rejected the inferiority of women, wrote with feeling about the burden imposed upon them by Broca's numbers:

Women displayed their talents and their diplomas. They also invoked philosophical authorities. But they were opposed by *numbers* unknown to Condorcet or to John Stuart Mill. These numbers fell upon poor women like a sledge hammer, and they were accompanied by commentaries and sarcasms more ferocious than the most misogynist imprecations of certain church fathers. The theologians had asked if women had a soul. Several centuries later, some scientists were ready to refuse them a human intelligence.

Broca's argument rested upon two sets of data: the larger brains of men in modern societies, and a supposed increase in male superiority through time. His most extensive data came from autopsies performed personally in four Parisian hospitals. For 292 male brains, he calculated an average weight of 1,325 grams; 140 female brains averaged 1,144 grams for a difference of 181 grams, or 14 percent of the male weight. Broca understood, of course, that part of this difference could be attributed to the greater height of males. Yet he made no attempt to measure the effect of size alone and actually stated that it cannot account for the entire difference because we know, a priori, that women are not as intelligent as men (a premise that the data were supposed to test, not rest upon):

We might ask if the small size of the female brain depends exclusively upon the small size of her body. Tiedemann has proposed this explanation. But we must not forget that women are, on the average, a little less intelligent than men, a difference which we should not exaggerate but which is, nonetheless, real. We are therefore permitted to suppose that the relatively small size of the female brain depends in part upon her physical inferiority and in part upon her intellectual inferiority.

In 1873, the year after Eliot published *Middlemarch*, Broca measured the cranial capacities of prehistoric skulls from L'Homme Mort cave. Here he found a difference of only 99.5 cc between males and females, while modern populations range from 129.5 to 220.7. Topinard, Broca's chief disciple, explained the increasing discrepancy through time as a result of differing evolutionary pressures upon dominant men and passive women:

The man who fights for two or more in the struggle for existence, who has all the responsibility and the cares of tomorrow, who is constantly active in combating the environment and human rivals, needs more brain than the woman whom he must protect and nourish, the sedentary woman, lacking any interior occupations, whose role is to raise children, love, and be passive.

In 1879, Gustave Le Bon, chief misogynist of Broca's school, used these data to publish what must be the most vicious attack upon women in modern scientific literature (no one will ever beat Aristotle). I do not claim his views were representative of Broca's school, but they were published in France's most respected anthropological journal. Le Bon concluded:

In the most intelligent races, as among the Parisians, there are a large number of women whose brains are closer in size to those of gorillas than to the most developed male brains. This inferiority is so obvious that no one can contest it for a moment; only its degree is worth discussion. All psychologists who have studied the intelligence of women, as well as poets and novelists, recognize today that they represent the most inferior forms of human evolution and that they are closer to children and savages than to an adult, civilized man. They excel in fickleness, inconstancy, absence of thought and logic, and incapacity to reason. Without doubt there exist some distinguished women, very superior to the average man, but they are as exceptional as the birth of any monstrosity, as, for example, of a gorilla with two heads; consequently, we may neglect them entirely.

Nor did Le Bon shrink from the social implications of his views. He was horrified by the proposal of some American reformers to grant women higher education on the same basis as men:

A desire to give them the same education, and, as a consequence, to propose the same goals for them, is a dangerous chimera. . . . The day when, misunderstanding the inferior occupations which nature has given her, women leave the home and take part in our battles; on this day a social revolution will begin, and everything that maintains the sacred ties of the family will disappear.

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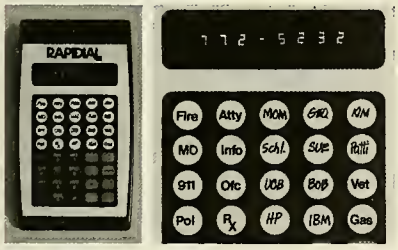
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I have reexamined Broca's data, the basis for all this derivative pronouncement, and I find his numbers sound but his interpretation ill-founded, to say the least. The data supporting his claim for increased difference through time can be easily dismissed. Broca based his contention on the samples from L'Homme Mort alone—only seven male and six female skulls in all. Never has so little given so much.

In 1888, Topinard published Broca's more extensive data on the Parisian hospitals. Since Broca recorded height and age as well as brain size, we may use modern statistics to remove their effect. Brain weight decreases with age, and Broca's women were, on average, considerably older than his men. Brain weight increases with height, and his average man was almost half a foot taller than his average woman. I used multiple regression, a technique that allowed me to assess simultaneously the influence of height and age upon brain size. In an analysis of the data for women, I found that, at average male height and age, a woman's brain would weigh 1,212 grams. Correction for height and age reduces Broca's measured difference of 181 grams by more than a third, to 113 grams.

I don't know what to make of this remaining difference because I cannot assess other factors known to influence brain size in a major way. Cause of death has an important effect: degenerative disease often entails a substantial diminution of brain size. Eugene Schreider, also working with Broca's data, found that men killed in accidents had brains weighing, on average, 60 grams more than men dying of infectious diseases. The best modern data I can find (from American hospitals) records a full 100-gram difference between death by degenerative arteriosclerosis and by violence or accident. Since so many of Broca's subjects were very elderly women, we may assume that lengthy degenerative disease was more common among them than among the men.

More importantly, modern students of brain size still do not agree on a proper measure for eliminating the powerful effect of body size. Height is partly adequate, but men and women of the same height do not share the same body build. Weight is even worse than height, because most of its variation reflects nutrition rather than intrinsic size—fat versus skinny exerts little influence upon the brain. Manouvrier took up this subject in the 1880s and argued that muscular mass and force should be used. He tried to measure this elusive property in various ways and found a marked difference in favor of men, even in men and women of the same height. When he corrected for what he called "sexual mass," women actually came out slightly ahead in brain size.

Thus, the corrected 113-gram difference is surely too large; the true figure is probably close to zero and may as well favor women as men. And 113 grams, by the way, is exactly the average difference between a 5 foot 4 inch and a 6 foot 4 inch male in Broca's data. We would not (especially us short folks) want to ascribe greater intelligence to tall men. In short, who knows what to do with Broca's data? They certainly don't permit any confident claim that men have bigger brains than women.

To appreciate the social role of Broca and his school, we must recognize that his statements on the brains of women do not reflect an isolated prejudice toward a single disadvantaged group. They must be weighed in the context of a general theory that supported contemporary social distinctions as biologically ordained. Women, blacks, and poor people (as well as children and criminals) were always mentioned together, but women bore the brunt of Broca's argument because data on women's brains were more readily available. Women were denigrated on their own accord, but they also stood as surrogates for other disenfranchised groups. We have seen the juxtaposition in quoted statements of Broca and Le Bon. Consider another from one of Broca's disciples in 1881: "Men of the black races have a brain scarcely heavier than that of white women." This juxtaposition extended into many other realms of anthropological argument, particularly to claims that, anatomically and emotionally, both women and blacks were like white children—and that white children, by the theory of recapitulation, represented an ancestral (primitive) adult stage of human evolution. I



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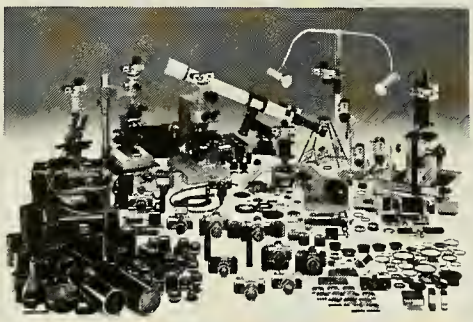
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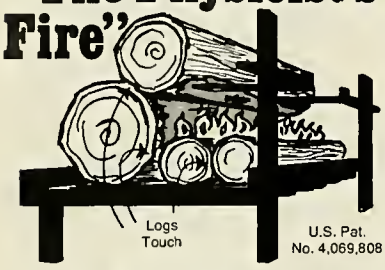
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From *Scientific American*
(August, 1978, pp. 142–146)

"Cranberg's conception of the radiation pattern from his log holder is correct . . . little of the radiated heat was lost upward to the overhang or the chimney . . . nearly all of it must have been coming out into the room."

"The burning was slower with this arrangement, and flames . . . were uniform across the length of the slot (cavity) and required no rotation or stirring of the logs."

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do not regard as empty rhetoric the claim that women's battles are for all of us.

Maria Montessori did not confine her activities to educational reform for young children. For several years she lectured on anthropology at the University of Rome, and she wrote an influential book entitled *Pedagogical Anthropology* (English edition, 1913). She was not an egalitarian. She supported most of Broca's work and the theory of innate criminality proposed by her compatriot Cesare Lombroso. She measured the circumference of children's heads in her schools and inferred that the best prospects had bigger brains. But she had no use for Broca's conclusions about women. She discussed Manouvrier's work at length and made much of his tentative claim that women had slightly larger brains if proper corrections were made. Women, she concluded, were intellectually superior to men, but men had prevailed heretofore by dint of physical force. Since technology has abolished force as an instrument of power, the era of women may soon be upon us: "In such an epoch there will really be superior human beings, there will really be men strong in morality and in sentiment. Perhaps in this way the reign of women is approaching, when the enigma of her anthropological superiority will be deciphered. Woman was always the custodian of human sentiment, morality and honor."

This represents one possible antidote to "scientific" claims for the constitutional inferiority of certain groups. One may affirm the validity of biological distinctions but argue that the data have been misinterpreted by prejudiced men with a stake in the outcome, and that disadvantaged groups are truly superior. In recent years, Elaine Morgan followed this strategy in her *Descent of Woman*, a speculative reconstruction of human prehistory from the woman's point of view—and as farcical as more famous tall tales by and for men.

I prefer another strategy. Montessori and Morgan followed Broca's philosophy to reach a more congenial conclusion. I would rather label the whole enterprise of setting a biological value upon groups for what it is: irrelevant and highly injurious. George Eliot well appreciated the special tragedy that biological labeling imposed upon members of disadvantaged groups. She expressed it for people like herself—women of extraordinary talent. I would apply it more widely—not only to those whose dreams are flouted but to those who never realize that they may dream—but I cannot match her prose. In conclusion, then, the rest of Eliot's prelude to *Middlemarch:*

The limits of variation are really much wider than anyone would imagine from the sameness of women's coiffure and the favorite love stories in prose and verse. Here and there a cygnet is reared uneasily among the ducklings in the brown pond, and never finds the living stream in fellowship with its own oary-footed kind. Here and there is born a Saint Theresa, foundress of nothing, whose loving heartbeats and sobs after an unattained goodness tremble off and are dispersed among hindrances instead of centering in some long-recognizable deed.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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A Fluke of Nature

A new grapefruit discovery may change your concept of fruit —

I'm a farmer. And the story I tell you is the absolute truth, as incredible as it may seem.

It all started in a grove owned by Dr. Webb, our family doctor. One of the men who was picking fruit in the doctor's orchard came up to the Webb house holding six of the strangest grapefruit anyone had ever seen! A single branch of an ordinary grapefruit tree had produced these six unusual fruit.

These were big grapefruit, unusually big, And they had a faint red blush on their skin. When Dr. Webb sliced open the grapefruit, the fruit was a **brilliant ruby red** in color.

Doctor Webb decided to taste this strange new grapefruit. The fruit was perfect, juicy and luscious. It wasn't sour like other grapefruit either — it was naturally sweet without sugar.

For some reason, we'll never know why, nature had chosen to produce an entirely new kind of grapefruit here in our Magic Rio Grande Valley. It was incredible — men had labored for years to produce the ideal grapefruit, and had failed. But suddenly on a single branch of one tree in one grove, Mother Nature had done it all herself!

YOU CAN IMAGINE THE EXCITEMENT

From the fruit on that one branch, grove after grove now produces our own Texas Ruby Red Grapefruit. When I say, "not one man in a thousand has ever tasted this grapefruit." — you can easily understand why.

To begin with, Ruby Reds are rare. You can look for them in stores, but I doubt if you'll find one. You may find pink grapefruit, but seldom if ever do you see the genuine Ruby Reds.

So you start with the rarity of Ruby Reds, and to get to ROYAL Ruby Reds you have to get rarer yet. Only 4 to 5 percent of the entire crop will qualify as a "Royal Ruby Red."

Each Royal Ruby Red weighs a pound — or more! Each has a rich red color, flowing juices, luscious naturally sweet flavor, and the ability to stay this way for many weeks.

Why, we won't even consider harvesting a grove until I've checked out the fruit for tree-ripened maturity myself. I check for "natural sugar," low acid balance and high juice content. I check to see that the fruit is plump and meaty, and I even check to see that the skin is thin. Not only does each factor have to check out, but all the factors have to be in a proper relationship to each other before I'll harvest a grove.

And when we pick the fruit we're just as fussy. Every one of us takes a "picking ring" when we harvest. If the



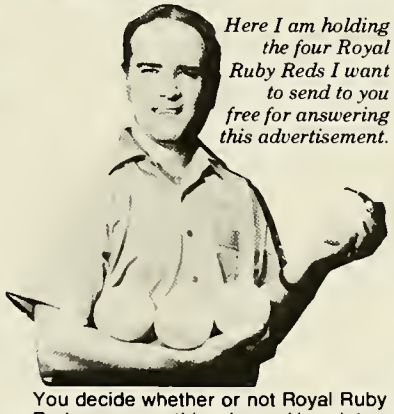
This is a picture of the actual harvest of this season's first Ruby Reds.

fruit is small enough to pass through this ring — we don't pick it! It simply isn't big enough to qualify as a Royal Ruby Red!

Even after picking there are other careful inspections each fruit must pass before I'll accept it. I size the fruit. And I grade it for beauty. Sometimes the fruit will be wind scarred. I won't accept it. Or sometimes it will have a bulge on the stem end that we call "sheep nose." I won't accept it. You can see I really mean it when I say I accept only **perfect** Royal Ruby Reds.

When I realized that the Royal Ruby Reds were the ultimate fruit, I decided to form a club and sell only to my club members. In this manner I can control my production to insure that nobody will be disappointed.

But before I ask you to join my club, I want you to sample my Royal Ruby Reds for yourself, at no cost to you whatsoever. Let me send you a box prepaid of 16 to 20 Royal Ruby Reds. Place four of them in your refrigerator until they are thoroughly cool. Then cut them in half and have your family sample this unusual fruit.



Here I am holding the four Royal Ruby Reds I want to send to you free for answering this advertisement.

You decide whether or not Royal Ruby Reds are everything I say. You determine whether or not eating a Royal Ruby Red is the fantastic taste experience I promise.

You decide. I'm confident that you and your family will want more of this superb fruit - and on a regular basis, too. If the four Royal Ruby Reds make you say "yes," then keep the remaining fruit. Otherwise return the unused fruit (at my expense) and you won't owe me a single penny.

But you are never going to know just how wonderful genuine Royal Ruby Reds are unless you place your order right quick.

This way you are sure to receive your package containing 16 or 20 Royal Ruby Reds for you and your family to sample a few days before Christmas. But since the supply is strictly limited it's important to place your order now.

SEND NO MONEY NOW

I'll put the bill for $10.95 for this first shipment on the top of the box. That's a saving of $5.00 off the regular price of $15.95. All delivery charges are prepaid by me. Remit only after my Ruby Reds have proved themselves, otherwise you don't owe a thing.

Now suppose you do like Royal Ruby Reds — suppose you **love** them — can you be sure of getting more?

You surely can. By saying "yes" to my first shipment you have the privilege of automatically joining my Winter Fruit Club. Please be assured **you pay nothing in advance.** But each month during the winter I'll ship you a $15.95 pack of 16 to 20 orchard fresh, hand selected, hand picked Royal Ruby Reds.

Every Royal Ruby Red you receive will pass my tough tests. Each will weigh a pound or more. Safe delivery is guaranteed. This fruit is picked, packed and shipped each month, December through April.

You pay only after you have received each shipment. And you may skip or cancel any shipment, simply by telling me your wishes.

HERE'S HOW TO ORDER

Call my toll-free number below, or send your name and address to me at the address below.

Remember it obligates you to nothing, except making a taste test of the best grapefruit that has ever been grown. And this taste test is on me!

Of course, as you can well imagine, when I say supplies are limited — I'm not kidding! There's just so many club members I can accept before I must close my membership this year.

So to taste this "miracle" grapefruit, and have the opportunity to savor it each month during the growing season, be sure to place your order at no obligation today.

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Emergence of the Green Darner

Text and photographs by Jon Farrar

Most of the world's 5,000 known species of dragonflies are tropical. Of the mere 400 found in North America, one of the most widespread is the green darner, *Anax junius*. Its three-inch-long body, four-inch wingspan, emerald-colored thorax, bluish abdomen, and yellowish green face all make the adult green darner a conspicuous member of the continent's insect fauna.

These large dragonflies mate and lay eggs primarily during the late spring and early summer. A female whose eggs have been fertilized will seek a body of still freshwater. Having found a suitable location, she will hover just above the surface. She then lands on a plant stem, backs down until her abdomen is just beneath the surface, and using her raspy ovipositor, lays the eggs in the stem of an aquatic plant. The young hatch two weeks later, immediately wriggle free of their chitinous sheaths, and enter a larval stage that lasts up to a year. For a few days, the nymphs draw nourishment from a yolk sac retained in their abdomen. When this provision has been absorbed, they begin their lives of voracious predation.

All during the summer and early fall, camouflaged in greens, browns, and subtle stripes, the nymphs lie in wait among aquatic vegetation until some victim comes within range of their prehensile labium, a modified lower lip festooned with sharp teeth. The nymphs have catholic tastes and will attempt to seize almost anything that is smaller than themselves, but the larvae of mayflies and mosquitoes are their dietary staples. The nymphs are also cannibalistic and often prey on each other. In turn, fish and frogs make meals of the nymphs, and their mortality rate is high.

Few nymphs are mature before the onset of winter. Most enter a period of dormancy between their ninth to thirteenth instar, remaining inactive in the soft bottom mud until the following spring, when the warming of the water and a renewed abundance of food enable them to complete their maturation. The stage is now set for one of nature's most splendid spectacles —emergence.

For a number of days before the nymph is ready to leave the water, gross morphological changes take place. The nymph gradually darkens in color, from a mossy green to an opaque brown; the wing sheaths swell until they stand above the abdomen, an outward sign of the massive growth of powerful flight muscles; the compound eyes progressively enlarge until they meet in the center of the head; and as the tissues of the specialized labium degenerate, new mouthparts form to suit the adult's feeding habits.

Behavioral changes also take place as the time of transformation approaches. The nymph becomes listless and does not feed for several days. It moves nearer the water surface, toward shore and the water plants suitable for its impending climb into an aerial world. For a night or two before emergence, the nymph will perch on a rush or cattail, its head and thorax above the water because it must now take in oxygen directly. Finally the time for emergence arrives, usually an hour or two after dark, and the nymph leaves the water for the last time.

Some dragonfly species crawl up only a few inches above the water on the plant they have selected, but the green darner often ascends much higher. The nymph climbs slowly, anchors its tarsal claws, and swings its abdomen violently from side to side, testing its grip and insuring sufficient room for wing expansion. For the next hour the nymph remains motionless, belying the great changes going on under the larval skin. The thorax swells, the skin splits, and the head follows quickly until the emerged adult hangs head down, supported only by the abdomen, which remains in the larval shell. For about thirty minutes the adult hangs, waiting for its extended legs to harden and dry before righting itself. In a spasmodic thrust the green darner pulls itself up, grasps the remaining anterior portion of larval skin, and extricates its abdomen.

Blood surges through the body, and the crumpled wings begin to unfold; in less than half an hour they will expand and begin to dry. This is one of the most critical phases of emergence. Buffeting winds, a fall, or another nymph climbing the same plant can irreparably damage the expanding wings. Under ideal conditions the wings will harden and be ready for flight within three hours after the larval skin first ruptured.

Dragonflies are more susceptible to predation during emergence than at any other time in their life cycle, but for the green darner, nocturnal emergence offers some protection from predators. By dawn the newly adult green darner is ready for its maiden flight. The first one or two weeks of the adult green darner's life are spent away from water while the gonads and mature coloration develop. Males return to the water first and vigorously defend feeding and mating territory. For several weeks the adults will feed and mate on the wing and the female will deposit her eggs, thus beginning a new cycle.

Before emergence into adult form, the nymph seizes its underwater prey with a prehensile lower lip.





1

Having reached the top of a cattail, the nymph remains motionless for about an hour while many internal changes take place. The skin around the swelling thorax splits open (1) and the head and thorax pop out. For the next thirty minutes, the adult, supported by its abdomen, dangles from the plant (2) while its legs harden and dry. The adult then rights itself (3) and extracts its abdomen from the larval skin. As blood pumps through the body, the wings begin to unfold and expand (4). In less than half an hour, they start to dry and harden (5). Within three hours after the larval skin first ruptured, the adult green darner (right) is ready to take to the air.



2



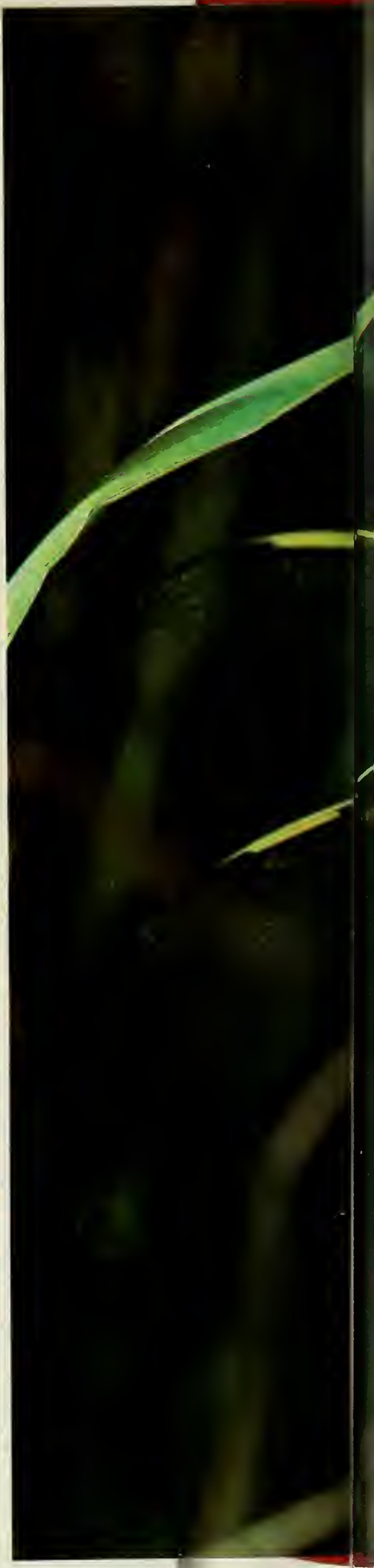
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4



5







Under and Around a Prairie Dog Town

by Harvey L. Gunderson

Gregarious and tenacious, these burrowing rodents have survived persecution by humans, predation, and a rigorous climate

A magnificent grassland once spread over the major part of central North America. From the edges of the eastern deciduous forest to the foothills of the Rockies, from Texas to Saskatchewan, the flat terrain was covered with undulating grasses on whose supple surface cloud patterns raced ahead of the wind. On seeing the waving grass stalks, Willa Cather wrote that the whole country seemed to be running.

The tallgrass that dominated the eastern portion of the grassland was the first glimpse of the prairie for the nineteenth-century pioneers who pushed west in search of farmland. The tallgrass was plowed under and the Corn Belt was born. Farther west there were vast seas of midgrass and shortgrass, which became known as the Great Plains. Farmers turned ranchers, and the grasses nurtured millions of cattle.

The transformation of the grassland into farmland and rangeland was not total, however. Although only small patches of the eastern prairie's tallgrass remain as relicts, and the Indian and buffalo have been pushed aside, much about the land has survived. It is still a place of extreme weather: searing winds in summer, blasts of frigid air in winter, and erratic precipitation throughout much of the year. Large patches of grassland still dot the Great Plains, and many grassland animals, adapted to the rigorous conditions, still carry out the routines of their existence.

A conspicuous survivor of the shortgrass faunal community characteristic of the Great Plains before the arrival of the white settlers is the black-tailed prairie dog. Poisoned and shot by ranchers, farmers, and local, state, and federal pest-control agents as part of a massive extermination effort that stretched over many decades, the nearly foot-long rodents have been greatly reduced from their former numbers, which ranged into the hundreds of millions. Nevertheless, the black-tailed prairie dog is still common in many parts of its primary range, from Texas north into Canada.

This gregarious mammal lives in large-scale communities, com-



Munching on a plant near its burrow, a black-tailed prairie dog, left, is well on its way to fattening up for the long, cold South Dakota winter. The animal's fat reserves, which account for its pear shape, will carry the prairie dog through spells of inclement weather when foraging is impossible. Dotting the landscape of a prairie dog town, right, crater-shaped mounds encircle burrow openings that plunge straight down.

Stouffer Productions; Animals, Animals

Joe Branney, Tom Stack and Associates

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Using its nose like a triphammer, a prairie dog tamps the earth around one of its burrow entrances. Such repair work usually is done after a rain, when soil can be easily moved around and packed.

monly known as prairie dog towns. One series of such towns, reported by the biologist C. Hart Merriam in 1901, was a veritable megalopolis, covering an estimated 25,000-square-mile area and containing a total (possibly exaggerated) of 400 million animals. The prairie dog no longer occurs in such numbers, but persecution of the animal because of its grass-eating and hole-digging habits has eased, and a gradual appreciation of the species has developed in some quarters. In Lubbock, Texas, a city park contains part of an original prairie dog town.

Members of the squirrel family, prairie dogs are consummate burrowers. Burrow systems range from about twelve to more than a hundred feet in length, and some reach down to a depth of fourteen feet. The burrows connect two, and rarely three, ground holes, which are surrounded by mounds. One mound is low and up to five feet in diameter; the other is narrow and up to three feet high. The low, wide mounds are dome shaped; the narrow, high mounds are shaped like craters.

The burrows are excavated from the low-mounded hole and completed with the construction of the high mound around the second hole at the other end. The low mounds contain subsoil material, while the high mounds are constructed of surface soil, grass, and burrow debris compacted into a hard surface by the prairie dogs. From the low-mounded hole the burrow angles downward, but from the crater-shaped mound the burrow plunges straight down, with an enlargement, or "turnaround" ledge, three to five feet below the surface. From there the prairie dog can "scold" terrestrial predators too large to enter the burrow and return quickly and easily to ground level after the danger has passed.

Passageways are from four to ten inches in diameter. Off these passageways, the prairie dogs hollow out a number of chambers. Those used for nesting are about twelve inches high and eighteen inches long and are carpeted or filled with grass. Other chambers serve as food-storage sites. Earthen plugs abound in the tunnels. They are a sanitary device, serving to seal off scats and dead prairie dogs. The arrangement of the plugs also results in a more complex burrow system, which may aid the prairie dog to escape some of the predators that do enter the burrows.

The black-tailed prairie dog has a host of predators. One, the black-footed ferret, is no longer much of a threat because it is extremely rare. Now on the Endangered Species List, this large ferret would enter prairie dog bur-

rows in search of its main prey. Avian predators include prairie falcons, which prey on the young; golden eagles; and red-tailed hawks. Bobcats, badgers, and coyotes hunt prairie dogs on the ground; bull snakes and rattlesnakes prey on them on the ground and in the burrows. Rattlesnakes feed mainly on the young and probably take an occasional adult.

Prairie dogs do most of their repair work on the mounds following a rain, when the soil surrounding a burrow entrance can be packed. First, the prairie dog cleans the passageways by pushing debris ahead of itself to the mouth of the burrow, then kicking it away from the hole with its hind feet. Then the animal hunches up on all fours and uses its nose as a triphammer to pack the moist material. Soil is added, and the sun bakes the mixture into a hard structure.

The mounds are attractive to other prairie inhabitants. In the past, bison used them for wallowing; they would paw and horn the mound into fragments, then wallow in the dust. Burrowing owls are closely associated with prairie dog towns and nest in passageways in unoccupied parts of the town. Rattlesnakes hibernate in the burrows during the winter. A variety of insects frequent the mounds, particularly on spring and summer mornings, and in turn, attract horned larks, lark buntings, and meadowlarks, which feed on the insects and use the mounds as watch and song posts.

The burrows and mounds are engineering feats that make possible the prairie dog's survival on the plains. The mounds minimize the inundation of burrows during the flash floods that occur on the hardpan plains and serve as observation posts from which the prairie dogs can see approaching predators.

The burrow system also helps the prairie dog cope with the environmental stress produced by the climatic extremes of the mid-continental plains. Maxwell Wilcomb, an entomologist working on prairie dog burrows and their insect inhabitants, has emphasized the stability of both temperature levels and relative humidity in the burrows as compared with those at ground level. Taking measurements during both the summer and winter, he also found considerably higher relative humidity in the burrows.

In late June, temperatures one inch above the ground surface varied from 77° to 99°F; three feet within a prairie dog burrow the variation was from 80° to 89°F. The temperature range was not only narrower but also cooler. Relative humidities during the same two-day testing period

The dirt flies when these rodents dig a burrow. This adult, furiously kicking away soil with its hind feet, lives in the prairie dog town situated in a city park in Lubbock, Texas.



Robert W. Mitchell; Animals, Animals

Robert Ashley Wilson



Sensing danger, a prairie dog issues a nasal warning bark that alerts other members of the town. The bark varies in frequency and intensity, depending on the nature of the threat.

ranged from 39 to 85 percent one inch above the ground surface; three feet inside the burrow the range was from 80 to 95 percent. Thus the range of relative humidity was narrower and higher inside the burrow.

In late December, again over a two-day period, Wilcomb repeated his measurements. The temperature one inch above the ground varied from 25° to 44°; three feet inside the burrow the variation was only from 42° to 48°. The temperature range was not only much narrower within the burrow, but also much warmer than the outside air. The relative humidity of the outside air over the same period varied from 52 to 89 percent; inside the burrow the variation was only 89 to 95 percent. Again, the range was narrower in the burrow, and significantly, the humidity was much higher than that of the outside air. The burrows not only moderate the harsh temperatures of the plains but, more important, help the prairie dog conserve some of the body water normally lost through respiration. This increases the animal's ability to survive with a minimum of drinking water, a scarce item in its environment.

Underground storage of food also helps the prairie dog to be independent of free-standing water. Plant material is hygroscopic and the air pressure in the burrows is subatmospheric. As the humid interstitial air in the soil is drawn into the side chambers, the stored food plants soak up a great amount of moisture. When a prairie dog eats in its burrow, it also consumes water.

Although prairie dogs are active in winter, the shortened daylight hours and periods of extreme weather reduce the time available for feeding. The fat reserves accumulated during the summer and fall and the plant material stored underground are important factors in enabling the prairie dog to survive this period. The animals spend much of their time underground in the deepest nest chambers, which have been well insulated with plant material.

For a mammal living in a confined space such as a burrow, the supply of oxygen is limited and the amount of carbon dioxide excessive. In some species, such as the pocket gopher, whose burrow openings are plugged (a closed system), physiological changes probably occur, enabling the animal to cope with carbon dioxide concentrations ten to sixty times higher than that of the outside atmosphere. Although elevated carbon dioxide levels and depressed oxygen levels lower metabolic activities, not much is known of their effects on pocket gophers. In a prairie dog burrow, the ventilation system produced by dissimilar burrow entrances at opposite ends of the passageways provides a sufficient supply of oxygen and prevents the concentration of carbon dioxide. When lighted candles are dropped into prairie dog burrows, the smoke is discharged exclusively from the opening with the high, crater-shaped, chimneylike mound. The convection current induced by the shape of the mounds permits exchange rates of oxygen and carbon dioxide that are adequate for the respiratory needs of the animals.

Rising on its hind legs to its full length, an adult prairie dog gives vent to a territorial call. The upward stretch is fast and strong, and juveniles often fall on their backs when they first try it.

Greg Beaumont







Clutching the prairie dog it has just captured with its powerful talons, a red-tailed hawk will soon have a full stomach. Other avian predators include prairie falcons and golden eagles.

Charles G. Summers

A black-tailed prairie dog town is a highly organized entity. Each town is a discrete unit, separated by unoccupied areas, rocky terrain, or a vegetational barrier. Nevertheless, the inhabitants of several nearby towns are often within sight of each other and have frequent contacts.

Towns are divided into two or more adjacent units called wards, separated from each other by topographical or vegetational features, such as a hill, stream bed, or trees. Social exchange between the animals in adjoining wards is frequent. Wards, in turn, are made up of coteries, the smallest closed social units of prairie dog society. A coterie consists of a cohesive group of individuals that defend a territory of about 0.6 of an acre. (For prairie dogs, the territory and the home range—the area used for feeding and reproductive behavior—are the same.) The coterie is based on the communal use by all its members of the burrow systems within the territory. Bonds between individual prairie dogs are reinforced by behavioral responses that serve to mold them into an organized social unit.

The composition of a coterie varies widely, but the average is one male, several females, and a half dozen young, not necessarily all related. One male dominates the coterie, even though other males may be members. The society is patriarchal, and the mating system is polygynous, that is, one male mates with several females.

There is one breeding season a year, February and March. The young, usually about four, are born after a gestation period of from twenty-eight to thirty-five days. Young prairie dogs remain in the coterie until their second year, at which time they begin wandering. New colonies and range extensions are created by those young that survive this period of greatest mortality and by exploring adults that may be trying to evade the constant pestering by the



H. L. Eijdenson



Charles G. Summers



young in the established coterie.

To maintain this highly integrated social system, especially within the coterie but extending to other coteries, and even wards, in the case of approaching predators, an effective system of communication has developed. The system is based on tactile, olfactory, visual, and vocal cues: the first three function primarily within the coterie; vocal communication extends beyond the coterie.

The most frequent method of identifying members of the coterie is the "kiss." Whenever two individuals meet, they approach each other with mouths open and teeth bared; they then touch mouths. If the individuals recognize each other, the encounter is peaceful. If they don't, they lie down on their bellies, wag their tails, and slowly creep toward each other. The resident prairie dog then usually routs the interloper. In this manner, the integrity of the coterie is maintained.

Grooming is another form of communication that enhances group cohesion. The young are particularly responsive to grooming and continually pester other individuals for attention. They are usually not denied and are among the most pampered juveniles in the animal world.

Vocalization is one of the strik-

Hunting prairie dogs during the early evening hours in Wind Cave National Park, South Dakota, a coyote noses around a burrow (top left). The unimpeded views characteristic of prairie dog towns and the animals' vocal alert system mean that the coyote is usually unsuccessful. The more successful terrestrial predators are those that can enter the burrows. Bison (bottom left) are fond of breaking up prairie dog mounds with their horns and hoofs and then wallowing in the rubble. Often, burrowing owls (below) can be found nesting in abandoned burrows in the deserted sections of prairie dog towns.



William A. Paff, Tom Stack and Associates

ing features of a prairie dog town. The most common is the nasal warning bark, which is accompanied by a flick of the tail. The bark varies in frequency and intensity depending on the degree of the danger. The territorial call is another distinctive vocalization. When giving this call the prairie dog thrusts its body upward to the length of its hind legs, points its nose in the air, and stretches its forelegs out. The upward stretch is quick and powerful, and youngsters flip over backward the first few times they try it.

Visual and vocal communication are made more effective by the manipulation of vegetation. Short grasses and forbs predominate in established prairie dog towns because the animals remove tall vegetation. This clears the view, particularly for a prairie dog perched on a mound, and an approaching coyote, for example, can be quickly spotted. The nearest prairie dog immediately begins vocalizing, and the warning signals spread throughout the town. The vocal alerts minimize the danger and reinforce the social cohesion of the town.

Prairie dogs feed primarily on plants but are opportunistic enough to take many insects during spring and summer. During late spring, summer, and fall, they eat mostly foxtail barley, grama grass, buffalo grass, white pigweed, yellow wood sorrel, and other plains grasses. Stems, leaves, seeds, and seed heads are consumed. In the late fall they will eat clumps of prickly pear. Their habit of trimming the taller grasses around their burrows encourages the growth of forbs, which they also consume. The forbs, which often have a more luxuriant growth than grasses, actually increase the vegetative mass per given unit area, thereby increasing the prairie dog's food supply. This diet turns the slender prairie dogs of summer into pear-shaped sacs of fat during the fall. The stores of fat enable them to survive the hazards of winter, when at times of severe weather they cannot emerge from their burrows for several days.

Despite great persecution by humans, the prairie dog, believed to have been more numerous at one time than the now extinct passenger pigeon, did not suffer the same fate. The prairie dog's adaptations have been finely honed and tempered to mesh with a demanding environment. This medium-sized rodent, with its towns and social organization, should remain a feature of the central North American plains for generations to come. □

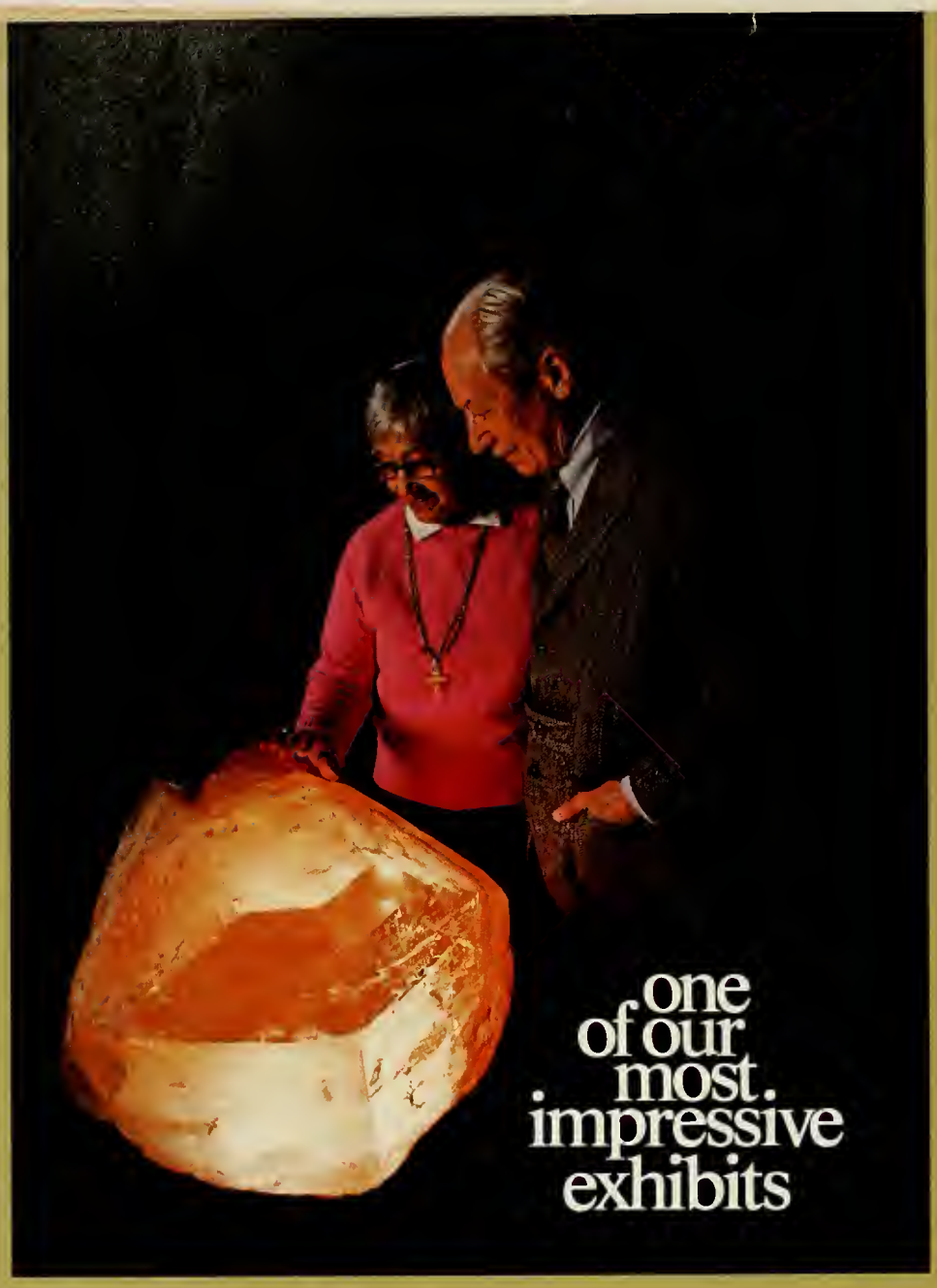
Mutual grooming (right) is an important type of tactile communication among prairie dogs. This behavior functions primarily within the coterie and serves to reinforce social bonds. Juveniles are particularly responsive to grooming and pester adults for attention. Their constant demands can so irritate an adult that, at times, a youngster is roughly shoved away (below).



Robert W. Mitchell; Animals, Animals

Anita S. Este





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SPACE WATCH


2A


2B

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2C

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2D

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5A



5B

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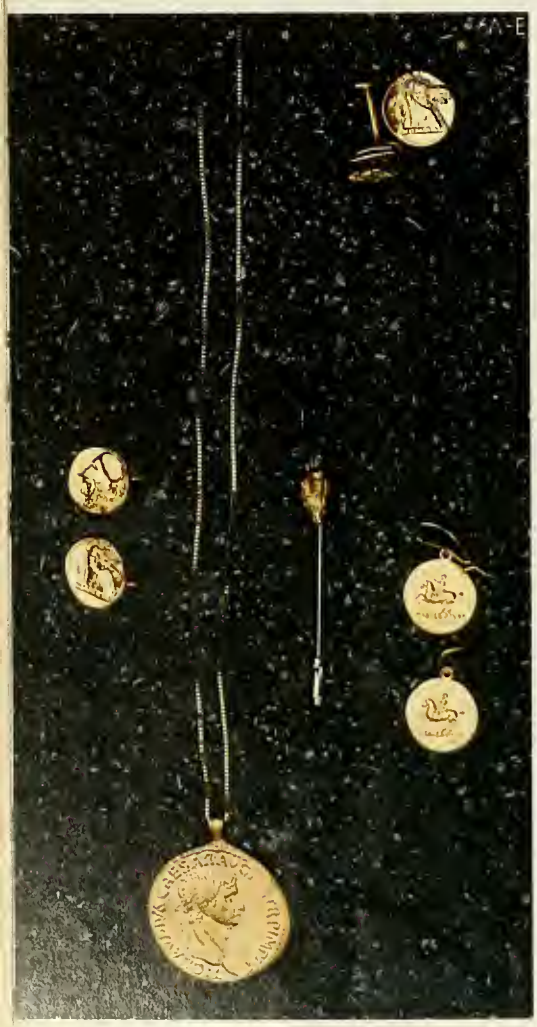
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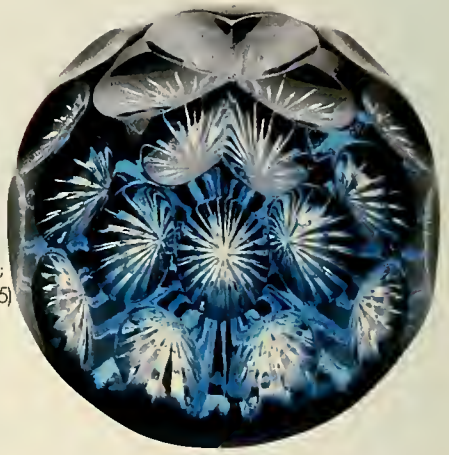
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6F

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8A



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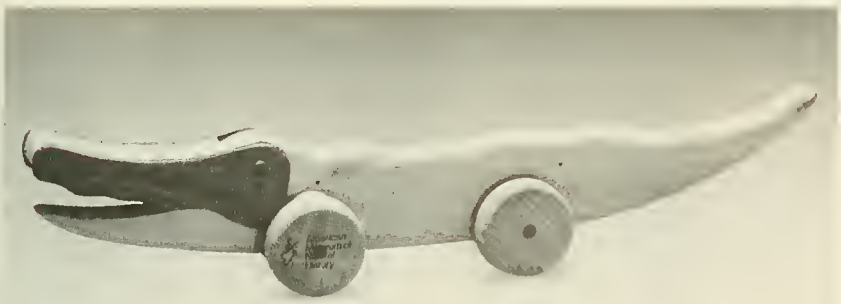
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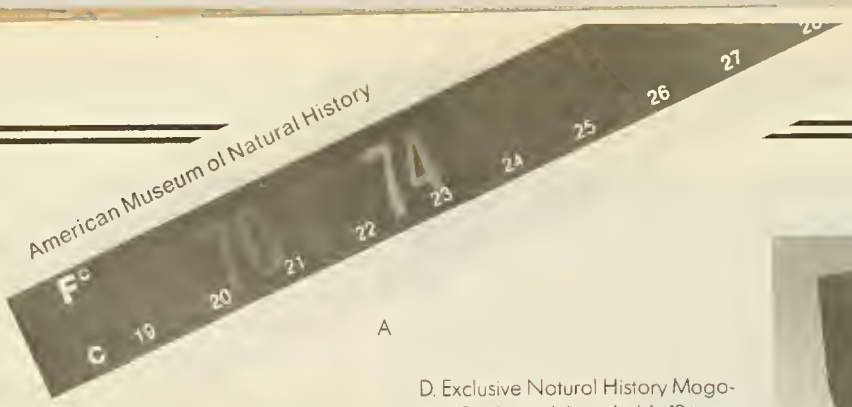
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A



B



C

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D. Exclusive Natural History Magazine Binder with logo holds 12 issues and records volume number, year. Textured leatherette. Green. #225. $4.95. Member $4.50 (1.25)

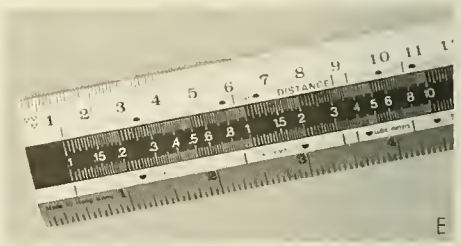
E. International Metric Converter Ruler operates with a slide rule to calculate distance, volume, length, weight and temperatures. Measures inches and centimeters. Aluminum ruler; plastic slide. 15"L. #226. $8.95. Members $8.00 (1.95)

F. The "everything" pocket knife in chrome with six quality stainless steel tools: scissors, screwdriver/bottle opener, can opener, nail file, 2 blades. 3" L closed. #227. $18. Members $16.25 (1.25)

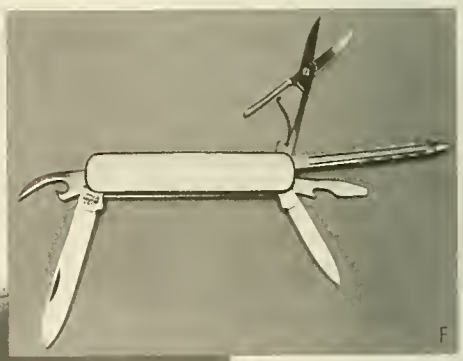
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D



E



F



G



9A. Imported from China. Exquisite genuine silver and turquoise antique bookmarks available in limited quantities. Each design is different but similar in shape and color. 5"L. #159. $30. Members $27 (1.25)

9B. The Poppy Box. Shiny brass-coated wood box brightened with blue and red baked enamel lid design. A decorative stash cache, 3" x 3". #160. $16.50. Members $14.85 (1.95)

9C. Tiny World Time Travel Clock* fits in your pocket or the palm of your hand. A space-age electronic marvel with 6 transistors and 4 jewels. Operates for 1 year on single replaceable AA battery. Front panel with rotating disc can be coordinated with local time in cities around the world. Includes black leatherette case. 4¼" x 1⅝"H x 1⅛" diameter. #161. $32. Members $28.75 (2.95)





9C



9D. Genuine Rattan Rocker imported from Asia. Perfectly scaled child-size design in dramatic "burned" finish. 13½"W x 20"H. #162. $35. Members $31.50 (3.95)

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EVOLUTIONS



10A. Original Paul Haff Crystal Sculptures. Art works of appreciating value, limited to an Edition of 10,000. Each piece is hand-scribed by the artist; bears a certificate of authenticity and the hallmarks of Sweden's Kosta Glassworks and the American Museum of Natural History. #168. Tyrannosaurus Rex, 5⅞"H, 3¾"L. $87.50. Members $78.75 (1.95). #169, Brontosaurus, 3½"H, 7"L. $77.50. Members $69.75 (1.95)



10C 10B

10B. Copenhagen Equatorial Sundial revives "gnomonics," the art of telling time by the sun's shadow that dates back nearly 22 centuries. Adjusted to the proper latitude, it will tell accurate solar time anywhere in the Northern Hemisphere. Sond-cast bronze with antique finish; copper orbital band and brass arrow shaft. 20"H, 14½" diam.; base 4" diam. #166. $225. Members $202.50 (6.95)



10C. Our Exclusive "Brantasaurus" Tie. The pre-historic beast runs loose on wrinkle-snubbing polyester woven in France. Fully lined. In navy or cognac. #167. $12. Members $10.75 (1.25)

10D. Ice Age Cave Paintings, circa 35,000 to 10,000 B.C. share the secret and exciting world of Cro-Magnon artists. Their mysterious signs, symbols and designs are faithfully reproduced on fine porcelain for practical 20th century living. #164, Quiche. $20. Members $18. #165, Cake Plate. $18.75; $16.85 (1.95)



11A. The Emu, Australia's bird of paradox that's large but smaller than the ostrich it resembles; that's flightless despite a pair of feathered wings. Our brass reproduction opens like a box to reveal a jumbo lucite egg (no two are alike). Some eggs are embedded with pyrite (that's fool's gold" while others have centers of assorted minerals. Stands 7" high. #170. $55. Members $49.50 (2.95)

11B. Bull & Bear art sculpture. Handsome bronze cast figures in natural setting of selenite mineral. Approx. 3" x 5" x 4". #172. $32.50. Members $29.95 (3.95)

11C. Sea Otter on Amethyst. What a life. Bronze cast otter back-floating in bliss and dining on abalone in geode of genuine amethyst mineral. Pewter base. Approx. 4" x 5" x 5". #173. $85. Members $76.50 (3.95)

11D. Geology Treasure. Genuine silicone carbide on 3" pronged brass stand. Dramatic collection piece. Approx. 3½". #174. $35. Members $31.50 (3.95)





12A

INDIAN IDIOMS

12A. Exclusive "Tesuque Indian" Design Collection created for the American Museum of Natural History. This distinctive geometric print was one of the traditional motifs of this early North American Indian tribe and was used to distinguish their clothing and dwellings. Interpreted in fine brown-beige Scotchguard woven fabric. #175. Folding Executive Portfolio. $48. Members $43 (1.95). #176. Clipboard with Metric Converter, Pen, Pad. $22; $19.75 (1.95). #177. Date Planner & Pen. $26; $23.40 (1.95). Not shown: #178. Attache. $150; $135 (3.95). #180. Pocket Secretary with credit card file, pad. $12; $10.75 (1.95)

12B. "Great Thunder," the Crow Dancer Indian sculpture by Boleslaw Cybis moves through the ritual of a magnificent tribal heritage. Limited issue of 100, masterfully executed in hand-painted parcelain. The original resides at the White House. 23"H. #181. $3875. Members $3487.50 ($27; allow 6-8 weeks delivery)

12C. A Portfolio of Indion Portraits by Edward S. Curtis. Rare and memorable reproductions of photogravure treosures capturing the spirit and sago of the North American Indians. The museum offers a selection of prints made directly from the Curtis originals, a project thot represents the largest photographic work ever accomplished by a single artist. Each folio includes 5 assorted prints (frames not incl.). #182. $20. Members $18 (1.50)


12B



12C

13A

13A. Genuine Alpaca Fur Rug. Found high in the Andes of Peru, Alpaca provides so much to the mountain Indians. This original design is made entirely by hand by Peruvian craftsmen. Approx. 4½' x 6½'. #183. $300. Members $270 (4.95)



13B

13B. Exclusive Tucan, a tropical fruit-eating bird in hand-painted porcelain. Imported from Venezuela. 10½"H. #184. $242. Members $217.75 (3.95)

13C. Peregrine Falcon, the powerful bird of prey revered in ancient Egypt and today an endangered species. Reproduced in solid brass. 8½"H. #185. $65. Members $58.50 (4.95)

13D. Indian Clay Planter. Authentically reproduced pottery bowl from Jemez & Aiz pueblos of Western America. Earthtones/turquoise. 13" diameter. #186. $22. Members $19.75 (1.95)

13E. Tribal Clay Platter, a ceremonial pottery server depicting original Indian designs from Acoma & Jemez pueblos. Hand-painted in earthtone colors. 5½"H, 9½" diam. #187. $25. Members $22.50 (1.95)



13C

13F. "La Palma" Bath Collection. Artist Fernando Llort translates scenes of his native South American village into a cotton terry towel ensemble. Brown with beige-rust. #188. King size towel. $18. Members $16.25. #189. Bath. $10; $9. #190. Washcloth. $2; $1.80 (.95 each; 2.95 set of 3)

13G. Pre-Columbian Art is Bolivian in origin and uses the same ancient tin working process it did centuries ago. These opulent artifacts are created from hammered metal. #191. Goblet, 6½"H. $31. Members $27.75 (2.95). #192. Tea Pot. $88; $79 (2.95). #193. Creamer. $38; $34.20 (2.95). #194. Sugar. $52; $46.75 (2.95). #195. Plate. $128; $115 (2.95)



13D-E



13F



13G

SEA CATCH

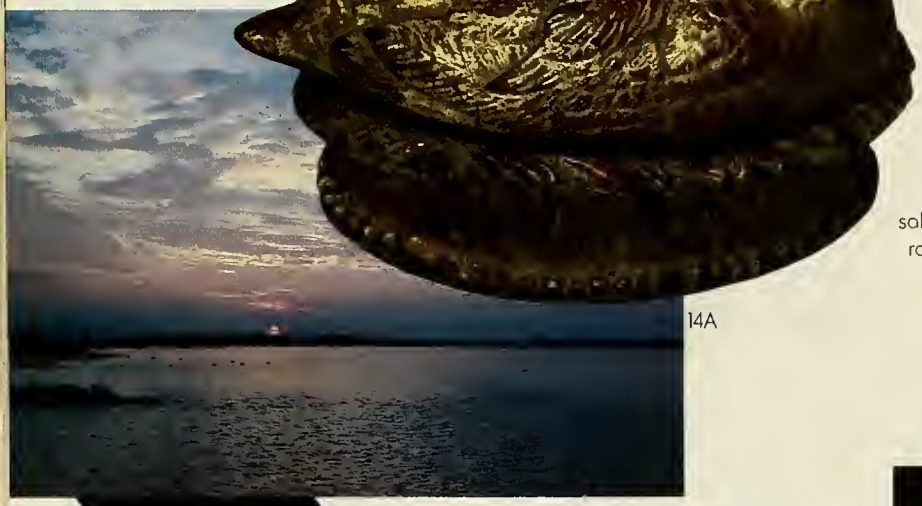


14A. The Duck Box. A natural clay cache reproduced with every winsome detail that makes this swimming bird a delight. Rust/gold. 7¼"L, 5"H. #196. $27. Members $24.25 (1.95)

14D. Snail collector's table. Nature's slow locomotor with magnificent dome shell reproduced in richly carved pine wood with antique brown finish. Thick glass top is 27½" diam. 28½"L, 16"W, 17"H. #200. $560. Members $504 (24.95)

14E. Sea Stowage in solid cast brass with fully hinged lids. #201. Sea Otter with Catch. #202. Turtle. Each, $30. Members $27 (2.95)

14F. Studious Sea Lions. Sleek reproductions in solid brass. Pair them for bookends or show separately as sculptures. 10"L, 8½"W, 12"H. #203. $140 each. Members $126 each (1.95)



14A

14B. Sea Insignias. Nautical solid brass belt buckles for 1½" belts. #197. Pinwheel Shell, 2¼" diam. $17.50. Members $15.75. #198. Fish, 2½" diam. $20; $18 (1.25 each) 14C. Hand-crafted calfskin leather belts, 1½" wide. In cordovan or dark brown. For men & women. Specify waist size. #199. $12. Members $10.75 (1.95)



14B-C



14E



14F

15A. Sea Cheers. Bodo crystal glasses beautifully etched and frosted with prized sea shells. Set of four 14-oz. double old fashions. #204. $14. Members $12.50 (2.50). Matching 32-oz. Pitcher, 7½"H. #125. $14; Members $12.50 (2.50)

15B. Sea Sculptures capture the captivating essence of nature's favorites. Created totally of natural materials (clays, feldspars, oxides), these creatures are completely crafted and painted by hand. #206. Seagull, 7¼", 4½"H. $37. Members $27 (3.50). #206. Baby Seal, 4½"L, 2½"H. $20. Members $15 (3.50)

15C. Sea Brights. A 4-part paperweight collection of aquatic life including the imaginative starfish and legendary nautilus. Cast in solid brass. #207. $92. Members $92.75 (3.75)

15D. Sea Shells. Shiny cast aluminum napkin rings in graceful sea shell designs. Set of 4, each 1" diameter. #208. $16. Members $16.25 (1.95)



15A-D



16A-B

16A. Eric Sloon Editions. Fine library of the renowned historian, artist and writer who recreates fascinating aspects of America's heritage. #209. Age of Barns, $17. Members $15.30. #210. I Remember America, $14.95; $13.50. #211. Look at the Sky, $10; $9. #212. Our Vanishing Landscape, $10; $9. #213. American Barns & Bridges, $10; $9. #214. Seasons of America Past, $10; $9. #215. Reverence for Wood, $10; $9. #216. America Yesterday, $10; $9. (1.25 each)

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16F

16E. Bride's "Blue Box." Authentic reproduction of early American "trousseau keeper" in hand-stenciled split wood with cotton lining. #220. $38. Members $34.25 (2.95)


16C

16C. "The Albemarle" Weather Station* by Taylor. Solid mahogany case fitted with barometer and thermometer (both F° and C° scales). Brass bezel and finial. 32" x 8½". #218. $200. Members $180 (6.95)

16D. The "Colonial" Globe by Replogle. 12" world with raised mountains, easy-to-read places. Walnut-finished cradle. 17"H. #219. $80. Members $72. (6.95)


16D



16F. The Hartsdale Regulator Clock* reproduced from an American classic in genuine walnut. Battery-operated movement strikes on the half-hour and tolls on the hour. Roman numeral parchment dial; swinging pendulum of brass. Hinged glass doors. 35" x 17" x 4½". #221. $200. Members $180 (6.95)

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Ceramics of the Canelos Quichua

by Dorothea S. Whitten and Norman E. Whitten, Jr.

In a changing environment, these people use ecological knowledge, dreams, spirits, and hallucinogens to guide their pottery-making tradition

Before sunrise, Laica sat down on a split bamboo mat and reached for the cool, damp clay at her side. During the night she had dreamed of water and of her husband, Taruga, trekking north to hunt game for the coming annual ceremony. Pungent smoke from the glowing wood fire penetrated the swirling, chilly mists that rose from the surrounding jungle hills.

She concentrated on her dream visions, seeking to integrate them with her knowledge of the environment. Segments of mythic episodes came to mind, and from them she selected images to guide her pottery making: Quilla, the roguish moon; Jilucu, the moon's sister-lover; and the Palu, the poisonous snake whose bite spells shamanistic death. The images became more vivid as she recalled songs about them and softly repeated these to her children while thinking of what she would create: a half-moon in the form of a cornet, a pregnant potoo bird, drinking bowls with her special designs, and a joined pair of deadly bushmasters.

This contemporary scenario reflects an ancient Upper Amazonian tradition that has been maintained by the Canelos Quichua of east-central Ecuador. It is a tradition that acts as a buffer against the cataclysmic changes brought by foreign influences. The Canelos Quichua inhabit tropical rain forests from the foothills of the Andes, east to the hills and swamps near the present border of Peru. Annual rainfall here averages between 150 and 200 inches.

The indigenous people of this region have experienced numerous disruptions for well over a century. In the late nineteenth century the Amazonian rubber boom reached this area, bringing a rush of Europeans. In the 1930s, oil exploration teams from Royal Dutch Shell penetrated the jungles, and colonists cleared land near Puyo and planted sugar cane. In 1941, during the Peru-Ecuador war, Peruvian soldiers invaded southeastern Ecuador. Since the 1950s a widening web of roads—its progress always followed by colonists—has begun to snake through the jungles. And then in the 1960s and 1970s, the oil exploration teams returned.

In this changing environment, the Canelos Quichua, like other indigenous societies of the Ecuadorian tropics, strive to maintain their ancient traditions while seeking a firm position for their expanding population. The 10,000 Canelos Quichua, many of whom have intermarried with Achuara Jivaroans, a neighboring people, practice swidden agriculture on three- or four-acre plots. Their basic crops—manioc, plantain, taro, palm, maize, peanut, and sweet potato—grow to vertical layers of vegetation, replicating the natural forest ecosystem, which forms a canopy that breaks and diffuses rainfall, filters sunlight, and provides a root lattice to retard leaching of vital nutrients. Before the soil becomes exhausted, men fell trees, creating another plot and allowing the first to return to forest. The people complement their carbohydrate resources with animal protein acquired through hunting, fishing, and the collecting of insects, larvae, land snails, tortoises, turtles, eggs, and river crustaceans.

The dietary staple, however, is *chicha*, a yeasty, gruellike drink made from cooked, masticated manioc. This food drink, rich in carbohydrates, also contains vegetable proteins that are increased through fermentation.

The Canelos Quichua have integrated their subsistence base with their social organization. The raising of manioc, for example, is representative of the fundamental



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Left, a Canelos Quichua woman forms a mucahua, *a traditional drinking vessel. Right, a* mucahua *stands before two small* tinajas, *modeled on larger storage jars for fermenting* chicha.

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Above, a mother and child pause in one of the new cattle pastures that intrude on the forest at the western edge of Canelos Quichua territory in eastern Ecuador. Right, only a few years ago, a hidden clay pit existed in this forest glen. Today, ubiquitous Cuban grass, planted for cattle grazing, has severely altered the local ecology by destroying the forest.

male–female division of labor: men clear land; women plant manioc. Women are also responsible for harvesting the crop, but may receive help from men. Making *chicha*, however, is strictly women's work.

Women also maintain the Upper Amazonian tradition of making both decorated pottery, which they use for storing and serving *chicha*, and blackened pottery, which is used for a variety of cooking and serving uses. The pottery-making tradition



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Manioc (cassava) supplies carbohydrates for the Canelos Quichua and other peoples of the tropical forest. Women, left, pull tuberous manioc roots from the ground, skin them, and wash them in the river. Above, a woman makes chicha, *a yeasty, mildly fermented drink, by pounding and masticating cooked manioc and storing it in a* tinaja.

is strongly tied to personal experience, familial integrity, ideology, and knowledge of the environment.

Basic to the ideology of the Canelos Quichua is a learning process through which knowledge and vision are integrated. They think of knowledge as specific information acquired from any source. That manioc yield decreases after two plantings, that caterpillars pupate into moths, and that government officials seldom listen to Indians when discussing the Upper Amazonian ecosystem are all considered retrievable pieces of useful information.

To the Canelos Quichua, vision comes primarily from dreams. They believe it is important to awaken after dreaming, so as to sift the jumble of images into an analyzable symbol system that relates past knowledge to present, observed behavior. A flash of insight in which one realizes the relation of dream content to previous knowledge also provides vision.

The Canelos believe in a biosphere of spirits: the master ones are Amasanga, the forest spirit; Nunghui, the pottery clay–garden soil spirit; and Sungui, a water spirit. Visions and the spirit world are closely tied. The Canelos Quichua use the powerful hallucinogen datura to enter this spirit world. The drug propels the taker into a six- to twelve-hour-long series of heightened visual and sensory episodes. Hallucinations continue sporadically for one to three days, as the taker resumes interactions with other humans in his usual surroundings.

The ceramic-making tradition, carried on only by women, reflects the synthesis of knowledge and vision. Girls and young married women learn techniques of hand building, painting, and firing from their own or their husbands' mothers. The decorative style, however, develops with a woman's growing knowledge and vision of her world. Once or twice during her lifetime, she may seek a deeper vision of the spirit universe by taking datura.

Husbands play an important but secondary role in the pottery-making tradition by helping to mine clay and by acquiring special stones used for making dyes and for burnishing. Mining itself is exciting, challenging, and grueling. Once or twice a year a small group of related women, together with their husbands and children, walk for a day or more through the rugged, hilly terrain to a clay pit or riverbank site ostensibly known only to them. There they dig with hands,

Victor Englebert

machetes, and sticks for a supply of nearly pebble-free clay, which they carry home on their backs—100 pounds for a woman, 150 for a man—with the aid of tumplines.

During mining, the women and men talk animatedly, their stories and jokes punctuated by ringing laughter. An undercurrent of excitement buoys them as they watch for special stones. Particularly prized are water-polished stones, certain textured rocks, and mineral-ore fragments that yield black and red dyes used to decorate pottery. Small, smooth stones are highly valued by both men and women, who use them to burnish drumheads and pottery respectively. The Canelos believe that a spirit that facilitates the merger of earth and water lives in such stones.

After the trek home, the women dry out lumps of clay by plastering them to the split palm or bamboo walls of their houses until they are of a workable consistency. The rest of the clay is stored in damp leaves. The potter then kneads the partially dried clay until it is of uniform plasticity and free of all tiny pebbles. After separating the prepared clay into small chunks, the potter, usually helped by a daughter, uses a turtle-shaped wooden board to roll out coils eight to twelve inches long and one to two inches in diameter. They build up a supply of coils so that they can work on several initial pieces.

To begin a *mucahua,* the traditional drinking bowl, the potter rolls the end of a coil into a small circle and presses it flat against the board to form the base. Walls are built up by pinching the coil against the base, and then continuing the pinching process of coil against coil. When the walls are several inches high, the woman smooths the coils with swift upward strokes of her fingers. After she evens the walls, she thins, widens, and shapes them with a calabash scraper, then puts the vessel aside on a split bamboo mat or rack to dry, and repeats the process on her next *mucahua.*

A daughter or daughter-in-law normally assists in producing the modest assortment of bowls needed for household use. Such help indicates serious apprentice status. If the intent is to produce a large volume of pottery for use in an upcoming ceremony, the potter's sisters may work alongside her daughters and daughters-in-law. Initially, the mood is quiet as they think of songs about the spirit inspirations of their creations. As work proceeds, they become more conver-



Norman E. Whitten, Jr.

sational, sharing news of recent events, discussing prospective marriage alliances for their children, and joking about clandestine love affairs. Younger children gather around to watch, sometimes making small animal figures out of a ball of clay. Occasionally, the women take a *chicha* break to relieve the fatigue that comes from sitting for hours on cold earthen floors with scant bamboo covering.

When the first *mucahua* is dry enough to hold new coils, the potter levels its top by biting it, spitting out small pieces of clay as she goes. Biting produces a remarkably even wall top and serves to score and moisten it for joining the next coil. After finishing the coiling, scraping, and paddling, the potter again evens off the top by biting and then smooths the tooth marks with a scraper, her fingers, or sometimes a moistened maize leaf.

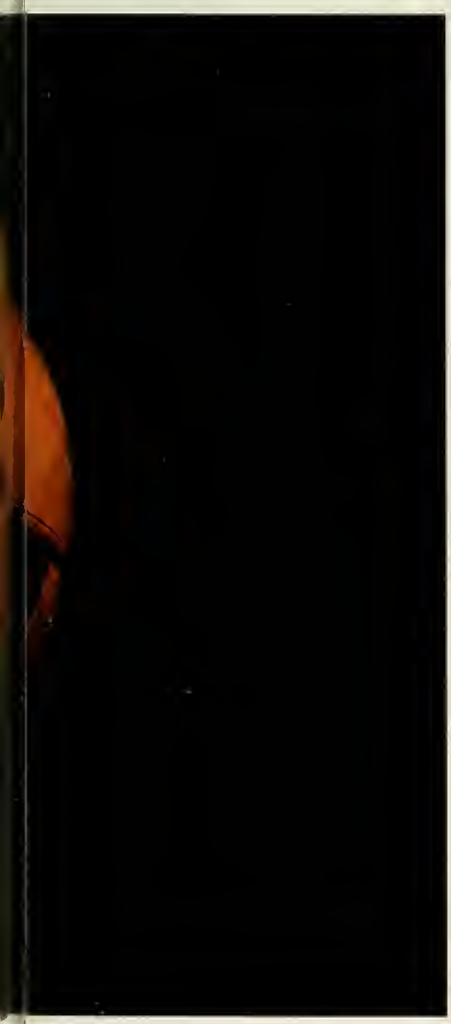
The women potters also use the coiling method to make vessels for storing *chicha*. These are much larger than *mucahuas*—sometimes two feet or more in diameter—and strong enough to hold the ten to twenty gallons of *chicha* mash placed in them weekly for five to ten years. Potters also create figurines from which to serve *chicha* during special ceremonies. These may take the form of fish, animals, or birds. Representations of humans or spirits are rare, but do occur. Examples include the form of a "cougar man," who dances and drums at ceremonies; the forest spirit; the garden soil–pottery clay spirit; an oil company worker; or a masked wrestler seen on a cinema poster. Rarer still is a replication of an ancient human burial urn adorned with four versions of a human head, each decorated as an Achuara Jivaroan's painted face.

Each ceramic is left to air-dry for a day or so, before being covered with slip—a clay thinned to a creamy consistency—usually white but sometimes pink or red. It is again air-dried until leather hard, then burnished with a smooth stone.

As pieces are drying, a woman will assemble her decorating equipment, sorting through the precious rock dyes she has attained from many sources and kept hidden since her last pottery manufacture. She chooses rocks that will yield various shades of red, black, and white when powder scraped from them is mixed with water. To the Canelos Quichua, a multicolored but predominantly red spectrum represents the domain of Sungui, master spirit of water life. Black and red are manifestations of Nunghui, spirit of garden soil and pottery clay.

A potter uses several delicate brushes with different-size tips, which she makes by fastening small locks of her own and her daughters' hair to little sticks. She names each brush according to its size and the color it will hold. She prepares the rock dyes in a stone vessel hollowed by years of grinding, then settles down on the floor to paint her special designs on the first *mucahua*, thinking of songs that relate mythic episodes to her day-to-day life.

First, she follows the tradition of adorning the bowl with a heavy





Norman E. Whitten, Jr.

A ceramic fer-de-lance, left, and a hard hat, below, have been made for an annual ceremony. The snake's design honors Sungui, the master spirit of water, and the hat's motif expresses shamanistic power.

Victor Englebert



Above, using a hot ember, a potter speeds the drying of her mucahua. *Right, women are responsible for carrying on ceramic-making tradition. Younger children watch women working on pottery and sometimes make their own small clay objects. Older girls become apprentices to their mothers or mothers-in-law.*

red line representing a female motif. She may know of several hundred base designs for the line, but she will choose from about thirty of her favorites, any one of which may be used to symbolize different aspects of the spiritual world. One zigzag motif, for example, may represent a winding river, which is Sungui's domain, or the spirit Nunghui manifested as a harmless brown snake.

Next, and again traditionally, she emphasizes the red-line design with fine black lines that stand for a male motif. These lines—painted either parallel to, surrounding, or radiating from the base design—signal a complex set of associations of husband–wife and brother–sister relationships. Fundamental to these relationships are combined concepts of warmth, togetherness, and ultimate continuity of male and female clan essence through women.

The decorations a woman paints on her ceramics are traditional in color and base design, but the choice and presentation of certain motifs expresses her individual integration of knowledge with vision. During the burnishing and decorating processes, a woman imparts three souls to each ceramic piece. The first is that of Nunghui. The burnishing stone, a representation of Nunghui's domain, symbolizes toads and frogs, basic to acquisition of male shaman power. This process is also symbolic of the power of Sungui. The second soul, that of the woman herself, represents the synthesis of knowledge, vision, and technique acquired through the process of learning. The third soul derives from the woman's household, a microcosm of the enduring biosphere.

Immediately after decorating the last of her *mucahuas*, the potter stokes a fire and makes a simple firing frame by chipping out the bottom of an old pot to form an opening slightly smaller than that of the rim of the *mucahua* to be fired. She then sets this frame upright over the logs and places the newly painted *mucahua* inside it, inverted over the hole. The *mucahua* is first covered with warm ashes and then heated gradually with hot ashes and glowing sticks.

After twenty-five to thirty minutes, the fire reaches a temperature of more than 1500° F. Within thirty-five minutes the frame is removed—with a pair of machetes held tonglike—and placed on the floor. The glowing pot is removed in the same manner and gently lowered to a log stool. When the bowl is cool enough, the potter rubs a wad of *shinquillu*, a tree resin, quickly over the entire bowl. The resin

deepens the colors, some transformed by firing, to their permanent intensity.

Canelos Quichua ceramics are used continually in daily life. Upon waking, a woman stokes the smoldering fire, procures water from a nearby stream, and boils it. She then mixes a handful of freshly fermented manioc mash into a *mucahua* of hot water and serves the tangy, yeasty drink to her husband. As men and women drink *chicha* in these predawn hours, they engage in animated discussion, relating the dreams they had just before awakening. They attempt to separate and integrate observations drawn from their encounters of the day before with the night's dreams. The mythic images of forest, soil, and water spirits are evoked by the designs on the bowls from which they drink. By reference to these images, they reaffirm their own strength and purpose, resolving yesterday's problems and reaching today's decisions.

As the day wears on, the Canelos Quichua continue to serve and drink *chicha*—in their houses, on their jungle plots, or in the forest. Although calabashes and aluminum bowls are readily available, the Canelos still prefer to use their handmade ceramics to serve and store *chicha*.

Men making long jungle treks or canoe trips carry one or two delicate *mucahuas* with them. Women choose particular *mucahuas* for serving *chicha* to guests. The more important the guest, the finer the piece. Today, near Puyo, where intrusion by outsiders is frequent, a woman may deny that she uses ceramic serving ware if she regards a visitor as a threat to her household or clan integrity.



Victor Englebert

Once or twice each year, the Canelos Quichua hold ceremonies that symbolize the relationship of their enduring culture to a changing world. Prior to such ceremonies women make an impressive array of ceramics, often taking over the entire household for their production. During this period, men conduct a special hunt for tapir, peccary, deer, and monkey, which they smoke in the forest and then bring home.

Preparations complete, a three-day ceremony begins with the men beating drums to signal the thunder of forest spirit Amasanga. Women dance in imitation of Nunghui and pour *chicha* into the mouths of participants, intentionally spilling much of it on the drinkers. Continuous drumming, plus a deluge of *chicha*, calls forth imagery of the encompassing power of the water spirit Sungui, whose presence is evoked to express resistance to further destruction of the Upper Amazonian ecology.

As the ceremony moves toward a crescendo, women serve more and more *chicha* from ceramic figurines representing fish, symbolic of Sungui's domain, and from reptile figurines, symbolic of Amasanga, Nunghui, and Sungui.

Ceramic images of recent environmental intrusions are also brought forth, such as a hard hat, shaped like those worn by petroleum company workers but adorned with an ancient reptilian design, and a jukebox complete with the name of the colonists' weekend saloon. As men and women drink *chicha* from these ceramic representations of a changing world, they think of the predawn song of the *paspanchu* bird, which, to them, means "evil is coming but I am ready to meet it." By simultaneously confronting the new with the ancient, the Canelos Quichua seek to maintain their sense of order in a radically changing environment. □

& ann noiñ essemus sicut nos. Nos uero é cõtrario paulisper
eum in faciem sicut p ysaiam dicit. filios genui & exalta
ui. ipsi uero spreuerũ me. Tunc paulisper eũ cum secu
rum sit creature potius q̃m creatori. Idcirco ascendit ipe
in altitudinẽ crucis. passusq; latere eius ecruit sanguis
& aqua in salutem nr̃am & unam ecclesiam. Noctua.

Noctua dicit. eo q̃d nocte circuolat. & p diem ñ possit
uidere. Nam grauo splendore solis ictus illius he
betatur. Noctua autẽ ñ est bubo. Nam bubo ma
ior est. Hic corax ipsa ẽ noctua. qua uocẽ amat. Est
enim auis lucifuga & solem uidere ñ patitur. Hec auis
figurã gentis iudeoꝝ qui uenien
te dño saluatore ad saluan
dos eos repulerunt eum dicẽ
tes. Non habemus regem nisi
cesarem. & plus dilexerunt te
nebras q̃m lucem. Tunc dñs
conuertit se ad nos gentes. & illu
minauit nos sedentes in tene
bris & umbra mortis. de quibꝫ
dicitur. populus quẽ non cog
noui seruiuit mi. & in alio pphete. Vocabo plebem meam
ñ plebem meam & c̃. Est de populo iudeorum filii alieni



Bubo à sono uocat compositũ Bubo. & cetera.
nomen habet. auis feralis. onusta quidẽ plumis
sed graui sẽp detenta pigritia in sepulchris die
noctuq; uersatur. & semp cõmorans in cauernis. De qua

An Owl Hunt

by Jean K. Lauber

The roots of modern science can be detected in the work of medieval artists

The decline of science in western Europe after the classical period, and the relative vacuum that remained in its wake, have been documented by historians of science. After genuflection to Aristotle, biological scientists have customarily dismissed the Middle Ages as a 1,000- to 1,500-year period that contributed virtually nothing to biology. The record is slightly better in botany because of the interest in plants as medicinals. Zoology, however, is usually not thought to have even begun as a distinct field of study until well after the Renaissance.

Some would place the beginning of true zoological study with Leonardo da Vinci's boundless curiosity and well-tuned sensitivity to the natural world; some with the scientific method of Descartes and Francis Bacon or with the encyclopedic naturalists such as Gesner; and some zoologists would not really feel at home with any progenitor predating John Hunter and Cuvier in the late eighteenth and early nineteenth century.

Yet the roots of this modern science lie in the Middle Ages. The science historian Lynn White, Jr., suggests that the evidence for the origins of zoology might be found in places where scientists have seldom looked:

> It is strange that historians of science have paid so little attention to the development of the visual arts. Art, like science, normally deals with the objects of our physical environment, and both art and science therefore presumably reflect any modification of attitude toward that environment. In view of the fact that the first stirrings of Western scientific curiosity are detected in the twelfth century, it is surely no coincidence that historians of medieval art have discovered a related change in the modes of aesthetic ex-

Two owls, left, one clutching a mouse in its talons, illustrate a twelfth-century bestiary. Below, an owl mobbed by smaller birds appears in an early Psalter.



British Museum

The British Library

pression beginning about the year 1140. The transition from Romanesque to Gothic charts the passage from an age indifferent to the investigation of nature to one deeply concerned with it.

My own search for the roots of my field, zoology, began as a study of English bestiaries and soon developed into an absorbing "owl hunt." It took me to illuminations in 800-year-old manuscripts, to woodcarvings in Gothic cathedrals, and to a charming twelfth-century poem, "The Owl and the Nightingale." In literature and naturalistic art, in oral folklore and folk medicine, especially of the twelfth to fifteenth centuries, I found evidence that there were indeed those who were carefully observing the natural world and recording their accurate perceptions of its inhabitants many centuries before zoology emerged as a recognizable discipline.

I define a zoologist as one who is interested in animals, who carefully and sympathetically observes and who accurately records what he learns about his subject. The methods of twentieth-century biologists differ vastly from those of preceding centuries because new tools are available to us. But the philosophy upon which the study of nature is founded is not new; indeed, as the owl record will show, it is far older than previously supposed.

In Judeo-Christian tradition, owls were unclean. They were predators and carrion eaters, and they lived in desolate places. In the Old Testament (Leviticus, chapter 11) is the charge:

> And these are they which ye shall have in abomination among the fowls; they shall not be eaten, they are an abomination: the eagle, and the ossifrage, and the osprey, . . . And the white owl, and the cormorant, and the horned owl, . . .

Presumably one had to know fowls and their habits well, in order to hold the right ones in abomination!

In classical Greece, on the other hand, the owl was sacred to Athena, the warrior goddess of superior wisdom, who was also thought to be capable of seeing in the dark. *Athene noctua*, the little owl that bears the name of the goddess, is so common in southern Greece that there is a saying, "bringing owls to Athens," with a meaning rather like "carrying coals to Newcastle." Coins of the period had the head of Athena on one side; on the other was the little owl. Indeed, the coins were popularly known as "owls" or "owl eyes."

The intellectual decline that began with the Roman takeover might be said to be paralleled by a deterioration in the reputation of the owl. Pliny tells us what the Romans thought of owls:

> The scritch owl betokeneth always some heavy news, and is most execrable and accursed in the presaging of public affairs. He keepeth ever in the deserts, and loveth not only such unpeopled places, but also those that are horribly hard of access. In truth, he is the very monster of the night, neither crying, nor singing out clear, but uttering a certain groan of doleful moaning. And, therefore, if he be seen either within cities or otherwise abroad in any place, it is not for good, but prognosticateth some fearful misfortune.

From Pliny also come indications about the usefulness of the owl to the medical practitioner, and it is worth remembering that recorded folk medicine reflects a much older tradition than its time. What Pliny records was probably common belief in his day—he would not have seemed so credulous to his contemporaries.

A recipe for pains in the sinews: "a horned owl's head, taken in honey, with root of a lily." Cataracts are cured by "the fresh gall of the *axio*, a kind of owl whose feathers twitch like ears" (or you can use "the heads and tails of mice reduced to ash, or pounded snails, or a viper burned alive in a new earthenware jug"). For drunkenness, "the eggs of an owl shall be given for three days in wine," and owls' eggs or the blood of an owl chick are effective in making the hair curly.

Another popular belief recorded



by Pliny was that owls hatch tail first because the weight of the head turns the egg wrong way up, and the chick thus "presents its hinder parts for the mother to cherish." To catch an owl, you should fix it with your eyes, then walk slowly around its perch three times, and the owl will twist its head off.

Some of this Roman and pre-Roman folklore was carried over into Britain with the conquest. Other beliefs and legends involving the owl were common throughout Europe, but their origin is lost to us. For instance, a farmer who persuaded an owl to live in his barn felt himself privileged to have acquired a guardian spirit and, incidentally, a good mouse catcher. One can still see barns with an "owl place" built in under the eaves.

Many of these legends were affected by Christianity, which gained such a strong hold on the medieval world. Of the few books circulating during the Middle Ages, one of the most popular, other than the Bible, was the bestiary. The bestiary was based on a fifth-century Greek or Alexandrian natural history, the *Physiologus*, a catalog describing the attributes of some fifty animals, including the owl. During ensuing centuries, the bestiary was copied and recopied by medieval scholars, sometimes rendered into verse, often illustrated (especially in the English versions), and frequently embellished by the monks who did the copying and illustrations.

To understand what happened to the animal descriptions in the written record, it is important to remember that this was an age of faith. As the Roman Empire deteriorated, the Church stepped in to provide the only social order and stability that were to be available for many centuries. The prevailing temperament, fostered by the Church, was otherworldly: the emphasis was on eternal salvation. It suited the purposes of the Church to instruct its unlettered people by use of picture books and fables.

In this context, the bestiary evolved into a series of accounts of what animals symbolized, what moral lesson was depicted by the real or supposed attributes of each creature. Saint Augustine even went so far as to say that what mattered was not whether an animal existed, but what it meant. Every part of an animal that was red symbolized the blood of Christ; the hatching of eggs was a reminder of the Resurrection; the predator and his prey represented the mortal struggle against the forces of sin; the nurturing of the young was a mirror of the love of God for his people. The bestiarist did not ignore or deny nature—he read into nature what the Church wished its people to know.

The treatment of the owl in bestiaries typifies this allegorical process. From a twelfth-century bestiary: "The owl Noctua, is so called because it flies at night. It cannot see by day, because its sight is weakened by the rising splendor of the sun. Owls thus represent the Jews, who refuse redemption. They love darkness more than light." Another twelfth-century account carries this "reasoning" one step further: it avers that, since the Jews are backward, the owl also flies backward!

The owl is described as a dirty bird that pollutes its own nest, frequents ruins and graveyards, and foretells doom. If an owl hoots near a sick person's house for three nights, that person will die. The screeching of an owl portends evil for a child that is born or means that a maiden will lose her virginity.

By the thirteenth century, the bestiary had grown to include about 150 animals, and the English versions, at least, distinguished between Noctua, the night owl; Bubo, the eagle owl; and Nicticorax, the night raven, also a kind of owl. This suggests that several different



Considered to be a "cat with wings," this particularly feline-looking owl is perched atop a tree in a hunting scene.

The British Library



kinds of owls were known to occur, although which of the now recognized species were intended is not clear. Five species of owls are native to Britain (the tawny, long-eared, short-eared, barn, and in the north, the snowy), the eagle owl is listed as a rare visitor, and the little owl, *Athene*, was introduced in the nineteenth century.

In popular belief, owls were thought to drink the oil from church lamps, a story that may have arisen as the fabrication of some sacristan attempting to explain the rapid disappearance of the valuable oil. This story is repeated in the text accompanying a charming woodcut in a late-fifteenth-century incunabulum entitled *Hortus Sanitatus* ("Garden of Health"). The book is primarily an herbal, listing the medicinal and culinary values of plants, but it includes almost one hundred entries on animals and even a section on rocks.

A number of accounts have dealt with the zoologically accurate observation that an owl is sometimes mobbed by smaller birds. Aristotle described the scene as involving admiration of the owl. And a fable of Aesop described the small birds as coming to seek wisdom from the owl, who had earlier warned them to beware of the hunter with the arrow: he would one day fit the arrow shaft with their own feathers and kill them with it. (The wise owl in legend was also the first to see the danger of mistletoe, which would be used in making birdlime to trap small birds.) But most mobbing scenes clearly depict the smaller birds as defending their space against the invader, who is unaccustomed to being abroad in daylight. The allegory was drawn: the owl represents Christ, who was "despised and rejected of men." Similarly, owl skins were nailed to barn doors by German farmers seeking protection against lightning. The parallel with the Crucifixion is apparent.

A twelfth-century poem clearly indicates that, beneath these allegorical overtones, the true reason for the mobbing was understood.



Courtauld Institute of Art

The nightingale, a traditional enemy, taunts the owl:

I know how cruelly you attack
Small birds who cannot fight
you back;
At every opportunity
You peck and tear them wantonly.
And that is why all birds
detest you.
Why when they find you they
molest you,
Screeching and crying as
they chase
And mob you till you leave
the place.
Even the tiniest of tits
Would gladly tear you into
bits!
For you are loathsome through
and through
And wholly hateful to the view.

The Owl and the Nightingale,
translated from Old English by
Brian Stone

Indeed, the mobbing phenomenon was put to use in the service of man: bird baiting was a standard form of hunting, and a stuffed owl was often used to decoy songbirds to a branch smeared with sticky birdlime. How else could four and twenty blackbirds—apparently the requisite number for one pie—have been captured?

The mobbing scenes depicted in manuscript illuminations and woodcarvings display a sense of proportion and a degree of naturalism unusual for the art of earlier centuries. In a delightful miniature from a twelfth-century manuscript, the magpie is clearly recognizable as the leader of the attack and can almost be heard protesting to the indifferent owl. The branch on which the birds are perched has a pleasing curve, although its leaves are stylized and botanically unrecognizable. Two of the attackers are truly airborne. The background is in the geometric "diapered" pattern supposed to represent stars in the sky.

About the middle of the twelfth century, man's attitude toward the natural world began to change, and art historians detect a trend toward greater naturalism in art. This was the time of transition from the Romanesque (Norman) to the Gothic style in architecture. The Carolingian churches had been decorated with rigid, stylized representations of plants, but now there was a new freedom: the stonemason seems to have had the very plant before him and to have tried to represent it accurately. In the foliated capitals of the early twelfth century, "one cannot be sure that the Romanesque sculptor was even thinking of leaves when he chiselled his boldly ornamental patterns." But by the end of the twelfth century, "the flora begins to become indented, lobed, elaborated, but it is still abstract." And then "about 1205 one finds intricately carved grape leaves . . . at Chartres; . . . and by about 1230 many species are clearly recognizable."

There were small hints of change in the climate of the times, although there was certainly no widespread intellectual movement. The spokesmen for the new order were rebels who dared to challenge the authority of the Church (while working within it) and were probably fortunate not to have ended at the stake. The evidence for the new naturalism is not to be found in the written record, which could never have been abundant at a time

At left, a gray owl is one of many creatures to be found on a page of a fourteenth-century "Monk's Sketchbook." The monk who carved the owl, above right, at Windsor Cathedral has apparently used the opportunity to ridicule a pompous bishop. Although the body of the carving represents a bird, the head is very human with unmistakable face whiskers and a hat.

Pepys Library, Magdalene College

when every manuscript had to be laboriously copied by hand. The evidence is mostly in folklore and literature and art, where modern historians of science have seldom looked.

The medieval naturalist shows that he knew the place of the owl in animal classification: the claws and the strong, hooked beak—the key taxonomic characters used today—are never missed by the artist. A thirteenth-century bestiary owl vies with the somewhat flowery script for the viewer's attention. The feathers are stylized, the stance a bit too horizontal—but the claws are entirely realistic. The beak even shows the external nares, and the artist was apparently so intent on showing the true shape of the beak that he even pictured the curve in a front-view portrait of the face (an artistic technique used by Picasso in more recent times)!

The twelfth-century poet cited earlier also knew the key characteristics of his bird. In a final exchange with the nightingale, the owl accuses her opponent of unfair tactics in calling forth the songbirds to defend her, rather than submitting their debate to impartial adjudication as agreed at the outset. Owl points out that she, too, could summon an even more formidable array of defenders:

> For birds with claws all sharp and bent
> And great hooked beaks for tearing meant
> Are my relations, all of whom
> If I requested help, would come.

Other aspects of owl morphology were carefully and accurately recorded: the flat face with large eyes and binocular vision, the cheek whiskers at the fringe of the face mask, the ear tufts, the upright stance. Sometimes these prominent features are caricatured for emphasis, as in the face mask of a Norwich Cathedral carving or the ear tufts of a fifteenth-century miniature, in which the head feathers parallel the outspread wings, and the bird seems to be posing briefly for the viewer before takeoff.

Habitat selection by the owl was known to medieval scholars: the preference for ivy and oak, the use of another bird's nest. In a woodcarving at Saint David's Church in Pembroke, an owlet seems about to try his wings from a perch among entirely realistic ivy.

Although ecology is a twentieth-century term and a modern discipline, the medieval naturalist knew the owl's ecological niche. This bird is a cat with wings. A hunting scene in the border of a fourteenth-century romance shows a remarkably catlike owl sitting at the top of a tree (but, interestingly, not the target of the archer). When the poet's owl boasts about the service she performs for the church; one imagines a barnyard mouser (feline) having the same pride in her profession:

> Nightly in God's holy house
> And in the barns, I hunt the mouse.
> I love to cleanse of filthy mice
> The church, beloved beyond all price.
> If I can stop it, I declare
> That nothing vile shall enter there.

The owl belongs with the predators; it is often shown with its captured prey. One of two owls in a twelfth-century bestiary stands on a mouse that can almost be heard uttering its last squeal, and a beautiful choir-stall woodcarving at Norwich Cathedral has an owl with a rodent in its beak. Owl pellets were known, although La Fontaine, the French Aesop, apparently thought they were mummified mice: one fable describes how an owl that had caught more mice than it could eat saved the rest in the bottom of a hollow tree, having first nipped off their paws so they couldn't run away!

In popular tradition, the owl has had a somewhat unsavory reputation as a bird of ill omen and is associated with the occult. One commonplace observation is that if you are afraid of something, you can take the edge off your fear by poking fun at the source of your apprehensions. So the owl, maligned throughout much of the long history of his association with man, was at times an object of derision. An owl in a Windsor Cathedral carving is a case in point. In Gothic churches, most of the choir-stall embellishment was done by master craftsmen, but the misericord carvings were often done by the monks. Apparently the monks sometimes



In the twelfth-century Bury Bible, *at Corpus Christi College, Cambridge, a tawny owl sits in an illuminated letter at the beginning of the Book of Deuteronomy.*

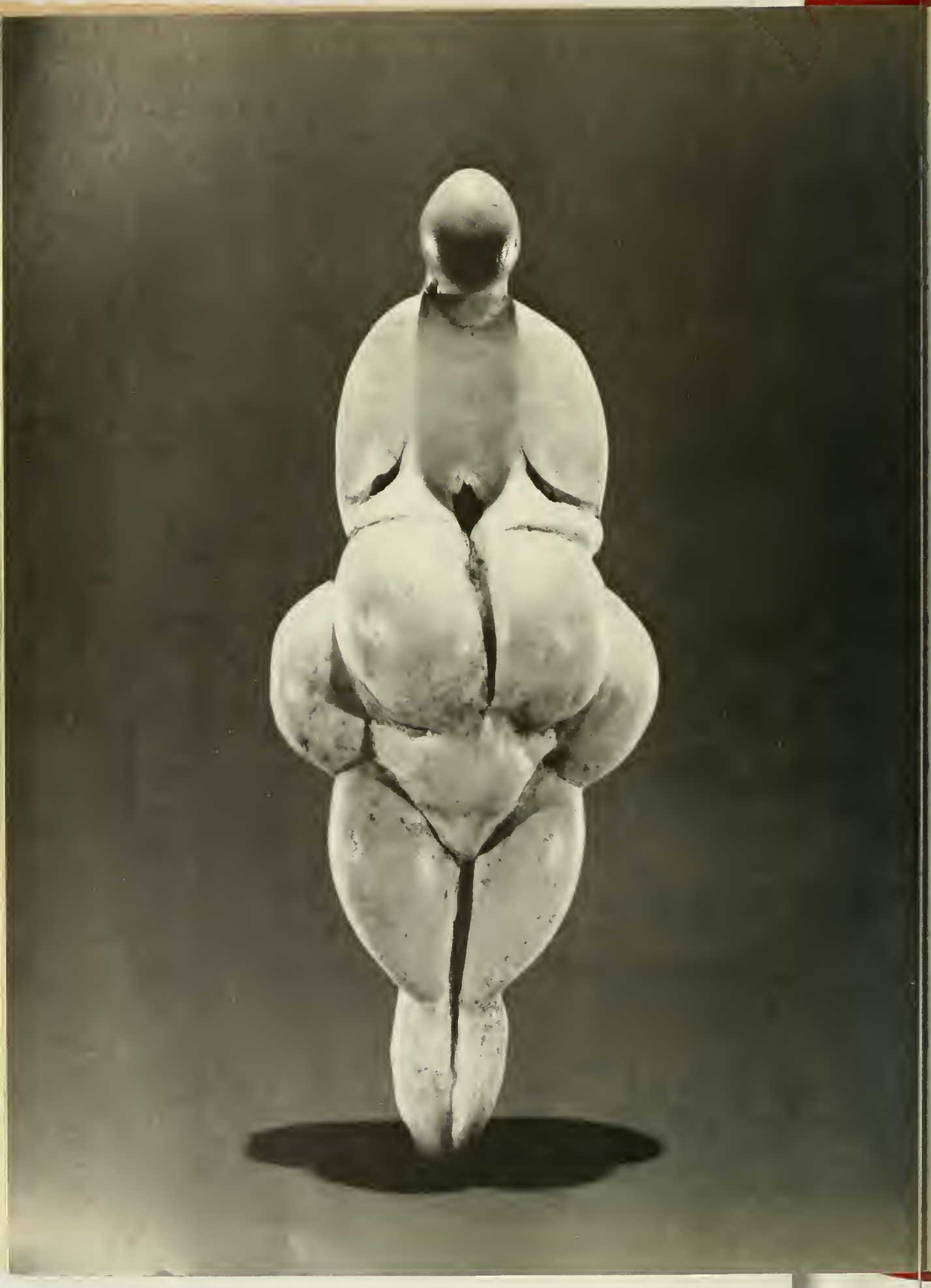
seized the opportunity to caricature the bishop: the Windsor owl has a very avian body, but the face mask displays the carefully groomed whiskers of, one imagines, a somewhat pompous superior. Even the archbishop and cardinals were not immune: a delightful miniature from a fourteenth-century manuscript has a fairly realistic, if slightly supercilious, owl wearing a red hat.

In a fourteenth-century Italian manuscript miniature, the owl's ear tufts are represented as donkey's ears and the tail is an ivy leaf. The bird seems to prance across center stage with one wing poised, owl eyes in his donkey face watching for the reaction of the viewer. In German tradition today, the owl occupies something of the same niche as the ass, representative of a stupid or foolish fellow.

But despite these humorous representations, the owl record shows that many medieval artists saw the familiar bird as an object of interest and beauty and presented it accurately. This record, from as early as the twelfth century, shows us the first evidence of a modern scientific approach in biology: the careful, systematic, and sympathetic observation of animals, plants, and natural phenomena. Textbooks of zoology did not exist during the Middle Ages, but there were intelligent observers of nature during that long, silent period. To find these kindred spirits, we must look to the folklore, the humanistic literature, and the art of the times. □



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The Modern Look of Ice Age Art

by Gerald Oster

Although made thousands of years ago, cave paintings and figurines of this early period seem quite up-to-date

One of the world's most famous art treasures, the Ice Age wall and ceiling paintings of the prehistoric cave of Altamira in northeastern Spain, was generally considered a fraud when discovered in 1879. A typical reaction was that the polychrome scenes of bison were executed by a French artist who happened to be visiting the Spanish nobleman and amateur archeologist whose twelve-year-old daughter first noticed the paintings. A prominent French archeologist of the period, Gabriel de Mortillet, spoke for his peers when he stated that "primitive man could not have painted with that slightly mediocre air of modernity." Indeed, the paintings of Altamira do have a modern appearance and could pass for nineteenth- or twentieth-century Western art.

Another immense collection of Ice Age (more specifically, Upper Paleolithic) paintings exists in the Lascaux cave in southwestern France. This cave was found in 1940 by four schoolboys who were searching for a lost dog. Like Altamira, the Lascaux cave primarily contains animal paintings that are thought to be associated with the hunt. The paintings consist of many overlays executed during different eras. Archeologists who have analyzed the Lascaux paintings have, to some extent, traced the evolution of the various styles employed.

Less spectacular than the paintings of Altamira and Lascaux are the small Ice Age ivory carvings and clay sculptures excavated by archeologists at sundry sites extending from Spain to the Ukraine. Many of these portable objects, known as *mobiliers,* have decorations that were evidently adopted by Neolithic man and were subsequently passed on to the ancient Greeks, the Vikings, and eventually to modern generations. Thus we are the inheritors of Ice Age art. Some *mobiliers,* the so-called Venus statuary, are abstractions of women that could be mistaken in a photograph for sculpture by such contemporary masters as Brancusi, Arp, Lipchitz, or Moore. (Engravings, photomurals of cave paintings, and carvings of prehistoric Europe will be on display at the American Museum of Natural History through the middle of January 1979.)

In their search for naturalism, the artisans of the Upper Paleolithic period (sometime between 20,000 and 10,000 B.C.) used artistic devices known as depth clues. Those early craftsmen must have wrestled with a problem faced by artists from the time of the Italian Renaissance down to the present, namely, how to give a three-dimensional, spatial feeling to illustrations on a two-dimensional surface. Like present-day art students, the artists of the Ice Age appear to have known those tricks of the trade that create an illusion of depth in a painting. Some of the paintings in Lascaux, for example, contain depth clues referred to as interposition and perspective. In other paintings, the roundness of the backs and bellies of animals

The Bettmann Archive, Inc.



Female figurines found in Ice Age caves at sites throughout Europe are all known as "Venus." The original of the Venus of Lespugue, shown in replica on the facing page, was found in France. The Venus of Willendorf, above, was found in Austria.

AMNH





Monkmeyer

The animal figures in this wall painting in the Lascaux cave were made during different eras. The reindeer in the center and wild oxen at the sides illustrate the technique of "twisted profile." The reindeer are also overlapped, creating a sense of depth.

is suggested by the subtle use of shading and color. In a few cases, the natural curvature of the cave surface was used to enhance the illusion of roundness.

Perhaps the simplest depth clue to execute is interposition. If the image of one object overlaps that of another, the overlapping figure appears to be in the foreground and the overlapped figure in the background. This effect is achieved, for instance, with a group of reindeer in a painting at Lascaux. Many of the animal figures at Lascaux were overlapped because they were painted during different eras. But all the animals in the reindeer group seem to have been rendered at about the same time; in terms of style and size, they are the same. The overlapping of these animals manages to suggest a herd and at the same time gives a three-dimensional feeling.

The reindeer of Lascaux illustrate still another depth clue, namely, perspective. In the reindeer painting the depth clue is that of twisted perspective. If a reindeer was shown in strict profile, only one horn would be visible. This is the technique used in some of the animal drawings at Lascaux. If, on the other hand, the artist wanted to show that a reindeer has two horns and at the same time wanted to keep the animal's muzzle in profile, two horns would have to be drawn on the profile in "twisted profile." The artists who painted the reindeer at Lascaux evidently wished to show the full magnificence of the antlers while keeping the animal's body in profile. The resultant use of twisted perspective suggests the dynamism

of a moving herd and creates the impression that the reindeer are turning their heads. This two-aspect representation has its modern counterpart in portraits produced by Picasso about 1940.

Perspective of a technically even more advanced level was also achieved by Ice Age artists. Some of the Lascaux bulls and many of the Altamira bison are shown in three-quarter perspective. In some cases the bison appear to be charging close to the observer. Their front hoofs are larger than their rear ones in accordance with the standard rules of perspective.

Examples of shading to enhance the impression of an animal's roundness are seen in the bison paintings of Altamira. Instead of sharply delineating the outline of the animal, the edges are softened with gradations of gray to suggest the manner in which shadow appears around a circular object. The use of gradation of shading in the manner employed by Ice Age artists is also a feature of European art, particularly of the realist school of nineteenth-century France as exemplified in the work of Courbet.

An extension of the use of gradients to achieve solidity is the application of gradations of color. This technique can be seen at Lascaux where the bodies of some animals are painted in subtle shades of yellow, brown, and red. The color-gradient technique employed to impart solidity is a feature of some of the paintings made by Cezanne in his later period, about 1875 to 1900; art historians acknowledge him as the first modern artist to deliberately use this technique.

Textural effects were achieved by Ice Age painters in a variety of ways. One method, widely employed in the caves of the Dordogne Valley in southwest France, is the application of pigment by means of a blowpipe. That technique, as applied to the mane of a horse at Lascaux, gives a soft texture to the hair as if the mane were matted.

Cave paintings, no matter where found, seldom show human representations. But there are many examples of Ice Age figurines that represent women. These objects are of fired clay or are carved from lignite or ivory. The exaggerated emphasis on breasts, buttocks, and vulva have suggested to archeologists that the figures are fertility charms. Sometimes the female form was completely abstract, represented as a round stone disk with a single cleavage.



In the search for naturalism, this painting of a horse from the Lascaux cave relies on outlining and shading, two devices still in use. The pigment in the horse's mane was applied with a blowpipe, producing a soft, matted effect.

Archeologists usually attribute this trend to the abstract to a late development in the history of Ice Age art. A similar trend can be found in Chinese calligraphy and in European painting and sculpture of the past hundred years.

Much has been written about the motivation of the artists of Altamira and Lascaux. Were they propelled by some deep religious conviction or were their paintings a form of self-expression, art created for art's sake? As with any other work of art, Ice Age painting stands on its own. Motivation is not relevant to the products of creation. Clearly, artists of the Ice Age were keen observers of animals in the wild. Their paintings were often executed with superb skill. The means they employed showed that in many cases they were masters of sophisticated techniques, some of which were rediscovered by a new generation of artists late in the nineteenth-century.

Gerald Oster, a professor of biophysics at the Mount Sinai School of Medicine of the City University of New York, is also a part-time artist. He has created a mathematical art form known as moiré patterns.



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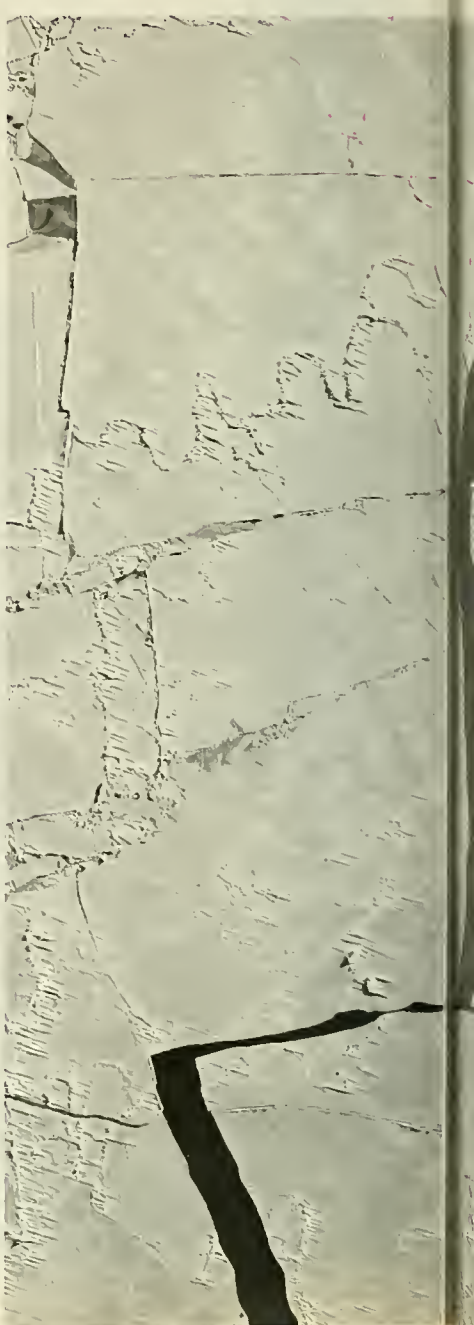
Oceans, Glaciers, and Mists

by Richard Goody

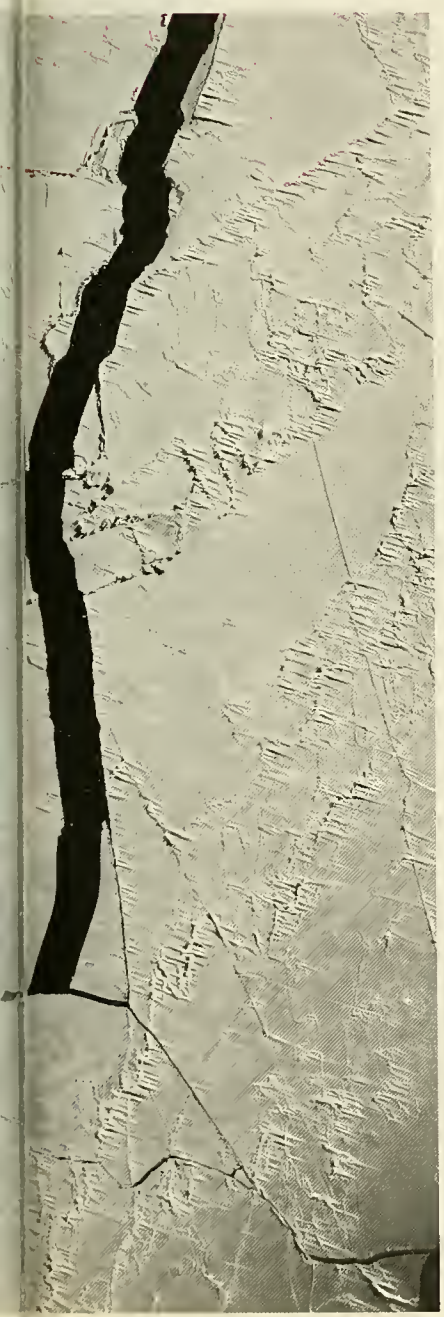
In one or another of its three forms, water plays a key role on Venus and Mars as well as on Earth

There is little need to dwell on the unique importance of water for our own planet. Water covers some 75 percent of the earth's surface; can exist in liquid, solid, or vapor form; and continually reshapes the small fraction of the earth's surface that rises above the oceans. Water is a crucial element in our meteorology, both as a source of heat released during condensation and as the substance forming the clouds that control the solar radiation reaching the planet's surface. As a chemical it is a powerful solvent, is highly reactive, and plays an essential part in many familiar processes. Above all, it is singularly important for biology, forming the bulk of most animal and vegetable tissues. Few life forms carry more than two or three days supply of this essential substance and all credible theories of the origin of life involve the presence of liquid water.

For more than a decade we have known that water vapor exists in the atmospheres of Mars and Venus and probably also in the outer



A satellite picture of the Arctic Ocean shows a large crack in the thin skin of ice. Water in this region falls in the form of ice but precipitation is very low. From a climatic point of view, the North Pole might be considered a desert.



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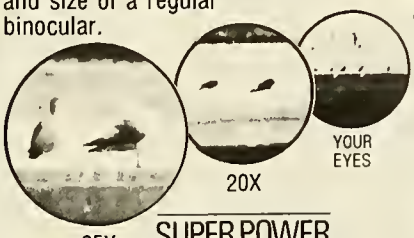
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solar system. The amounts detected are small, less than a thousandth of an inch if formed into a condensed layer, as compared with an inch or two on the earth. Nevertheless, the presence or absence of water can be almost as important for other planets as for our own, and I shall use it as a unifying topic, a text for the day, which transcends the classical divisions between studies of the earth and studies of other planets.

When I first began to write this article I was overwhelmed by the amount of material and the range of intriguing ideas that might interest the general reader. I have been selective and will present only a few topics to illustrate two general propositions: first, that many more facets of terrestrial behavior than are obvious depend upon water; second, that an overall view of the role of water on Venus, Mars, and Earth can be rewarding.

With respect to the first, I will deal with two unfamiliar ideas about the earth that are important for climatic change—the distribution of heat by ocean currents and the way in which permanent ice sheets function in a global context.

Let me start with the fundamental cause of atmospheric and oceanic motions—at least in the middle latitudes—namely, the transport of heat from the tropical regions, where most sunlight is deposited, to the polar regions, where the average annual insolation is small. For Earth, approximately half of this transport is associated with the movement of water, either in the atmosphere or by means of ocean currents. The division of the oceans into basins in conjunction with the earth's rotation leads to concentrated motions known as currents. The best known to the North Atlantic community is the Gulf Stream, which is largely responsible for making northern Europe habitable. I wish to direct attention, however, to two other currents, the Peruvian Coastal Current and the Tropical Counter Current.

The most important feature of Peruvian coastal waters is the upwelling of cold, plankton-rich antarctic water, which creates one of the bases of the Peruvian economy (fish, guano, and related products) and is responsible for the coastal climate. The cold coastal waters and the accompanying stratus clouds give rise to a cool desert—watered only by the few rivers flowing from the mountain ranges.

Tropical water, on the other hand, contains less nutrient, and evaporation from the warm waters often leads to torrential rains. Soon after Christmas each year, the boundary between the Tropical Counter Current (which flows close to the equator from west to east) and the Peruvian Coastal Current typically moves southward to about 2°S, in a phenomenon called El Niño ("the child"). But on some occasions (most recently in 1972–73) the boundary strays as far south as Lima (14°S). This flow of warm water results in an ecological disaster. Fish die and putrefy, discoloring ship hulls. The fishing industry is brought to a halt and the guano industry is affected. At the same time, the coastal strip, containing most of Peru's production and agriculture, is subject to disastrous flooding and erosion. This phenomenon demonstrates how dependent we can be on minor perturbations in the state of the oceans.

Among the inner planets, only the earth has liquid water on its surface. Mars is too cold and Venus is too hot for oceans to exist, at least at the present time. I will therefore turn to my second example of water-dependent terrestrial behavior, involving the flow of ice sheets rather than liquid water.

As has already been pointed out, one function of atmospheric motions in the middle latitudes is to transport heat toward the poles. In doing so, these movements usually also transport water. This is because the intimate contact between atmosphere and oceans insures that the air is close to saturation with respect to water. The water content of saturated air increases very rapidly with temperature so that warm air is moist and cold air is dry. Much of the heat exchange between the equator and the poles is caused by the mixing of warm—and moist—tropical air with cold—and dry—polar air, with water generally moving poleward in the same direction as heat. The heat carried to the poles is radiated away into space. The water, however, must precipitate and we must therefore identify the process responsible for carrying the water away.

Large amounts of water are not



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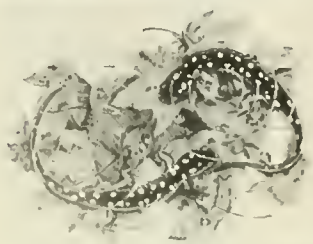
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involved. The precipitation in the polar regions is about an inch a year, so that, climatically speaking, the poles are deserts and among the driest areas on the earth. The water falls in the form of ice. This does not create a problem in the Arctic Ocean basin since the Gulf Stream penetrates there and keeps it liquid except for a thin surface skin of ice. The precipitation thus simply augments to a trivial degree the return flow from the Arctic Ocean to the global ocean system.

The Antarctic continent is more interesting since the precipitation there occurs on what is now a landmass. The falling ice collects at a rate of one or two miles in 100,000 years. The antarctic icecap has built up to about two miles above sea level, but the downward slope toward the periphery is enough for glacial flow to make a reverse circuit, returning water to the oceans in the form of ice calving from the continental ice shelf. The flow of ice from the shelf is at the rate of about 300 feet per year.

This water cycle, involving meteorological, glaciological, and oceanographic flows, is not only intriguing but also probable for any planet far enough from the sun for ice to form at the poles and whose atmosphere is saturated with water vapor. At one time it looked as if the Martian atmosphere might be saturated, at least at nighttime, in which case a similar water cycle might be expected. The precipitation at the poles would be a few hundredths of an inch per year, and elevation differences as great as five miles could build up with a glacial flow of about fifty feet per year from poles to equator.

I now doubt whether this happens on Mars, but its possibility was one reason for the *Viking* lander research with which I was associated. Nevertheless, there is a growing consensus that there are large amounts of ice below the Martian surface. This ice may not be visible since it would be covered by dust and debris, just as ice below the arctic tundra is covered with soil and vegetation.

Since water is so important in the inner solar system, it is proper to inquire, Where did it come from? To answer this question we must turn to the early history of the solar system. Geologists and geochemists present a consistent picture of the



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earth–moon system slowly evolving from an event that took place about 4.5 billion years ago—the condensation of the solar system from a rotating disk of hot plasma, which probably had the same average composition as the sun and stars have today.

To describe this cosmic mix in the simplest terms we may separate the elements into three general groups ranked according to abundance: first, hydrogen and helium, the lightest elements; then, oxygen, nitrogen, and carbon, classed with others under the term volatiles; and finally, iron, magnesium, and silicon, classed as refractories. Hydrogen and helium are between 100 and 1,000 times as abundant as the volatiles, which are, in turn, about 10 times as abundant as the refractories. Water (a compound of hydrogen and oxygen) and carbon dioxide (a compound of carbon and oxygen) belong with the second, or volatile, group.

Accepted theory states that as the plasma gradually cools, the first elements to condense—in the form of small dust particles—will be the refractories. The dust particles should collect quickly into planetesimals (small, solid bodies) and the planetesimals into planets, whose composition will depend upon the temperature of condensation, but some mixture of refractories, similar to the observed composition of the inner planets, is likely.

The planets will circulate through the remaining plasma, consisting principally of hydrogen, helium, and volatiles. At this point, the gravitational field of the planet will become effective and the planet can accrete a gaseous envelope from the gases.

If all of these ideas are correct—and they are strongly supported by a wide range of evidence—we can assume that at an early stage the inner planets had primitive atmospheres that consisted mainly of hydrogen and helium. Since the present atmospheres are completely different, we must assume that subsequent events wrought major changes. From a variety of possibilities, one is derived from our recent understanding of the moon, which indicates that an intense meteoritic bombardment took place between 4.5 and 3.9 billion years ago. The bombarding meteorites probably condensed

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in the outer solar system under colder circumstances than did the inner planets and therefore may have contained substantial quantities of ices formed from the volatile elements and their compounds: water, methane, ammonia, and mixtures thereof. This bombardment would have completely removed the primitive atmospheres of the planets and replaced the crusts with meteoritic debris.

This brings us back to the question, Where did the present atmospheres of the inner planets come from, particularly the water? The late William Rubey, a well-known American geologist, offered an answer thirty years ago when he pointed out that there is a resemblance between magmatic gases of several kinds, that is, gases within molten rock material, and the present atmosphere. It is possible that existing volcanoes, fumaroles, steam wells, and geysers may now be recycling material in our atmosphere. Nevertheless, we believe that Rubey's hypothesis—that water, carbon dioxide, and other volatiles all come from the earth's crust—is essentially correct. More speculatively, the earth's crust may have formed from the same meteoritic bombardment that shaped the lunar surface.

If this picture is valid, it offers the basis for a most important, unifying hypothesis for the atmospheres of the inner solar system, namely, that their similarities and differences may be accounted for in terms of the same scenario involving tectonic processes releasing from the crust the same basic mixture of volatiles. Other evidence leads us to believe that both Mars and Venus are tectonically active, as is the earth, but the amount and rate of emission could vary from planet to planet.

In case the adventurous nature of this hypothesis is not apparent, I should remind the reader of the large differences between these three inner planets in chemical composition, surface temperature, pressure, cloudiness, and many other aspects. I would like to discuss two of these—surface temperature and chemical composition—in more detail.

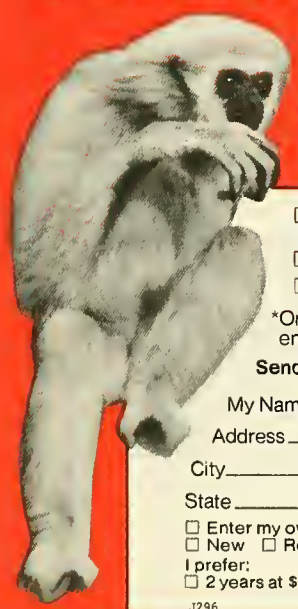
In "Climate and the Planets" (*Natural History*, January 1978), I described the runaway greenhouse effect caused by atmospheric water vapor and carbon dioxide. As these gases are slowly emitted from the crust, the sequence of events that follows will depend on the initial temperature of the planet, which depends, in turn, on the planet's proximity to the sun. For the coldest planet, Mars, the emitted water remains on the surface in the form of ice with only small amounts in the atmosphere in vapor form. That there is some water ice on Mars is certain: the residual summer polar caps are confidently identified as such. The possibility of much larger amounts of water bound up with the surface rocks must also be considered.

For the earth, the hypothesis predicts that more water than on Mars will remain in the atmosphere in the form of vapor but that the bulk of it will condense as liquid to form the oceans. That picture is so familiar it does not need to be emphasized. For Venus we concluded that all the water should remain in the atmosphere and that the screening effect for thermal radiation would greatly elevate the surface temperature, perhaps explaining why the surface of Venus is now at a dull red heat.

Thus, the same sequence of events that we have hypothesized leads to different physical states for the water and different surface temperatures on the inner planets. These two factors, in turn, can greatly influence the chemical history of the atmosphere subsequent to its emission since different chemical and photochemical reactions will operate under different physical conditions. This chemical history is a long and complex story, involving among other things the influence of living organisms in our own atmosphere. We believe that we understand a few of the processes involved, but we are a long way from accounting for the complete chemical history of any planet. If we do succeed, it may only serve to disprove our hypothetical, unified view of the inner planets.

One part of the story, however, can be isolated, namely, the escape of chemical species from the evolved planet back into space. The rate of escape depends primarily on two factors—the gravitational field of the planet and the temperature of the atoms at the height, or level, above the surface from

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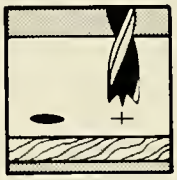
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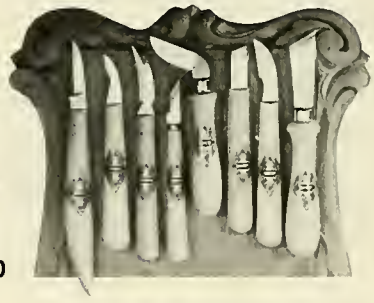
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which they can escape to space. Both factors differ from planet to planet: the former depends on the planet's mass; the latter, upon its closeness to the sun and the chemical composition of its atmosphere.

Before going further, let us pose a relevant question. If Venus's high surface temperature is related to the emission of tectonic water, where is that water now? There are small amounts of vapor in the Venusian atmosphere but they are trivial compared with the amount expected from our general hypothesis. Exposure of water vapor to sunlight can change the problem since the water will dissociate into its components, hydrogen and oxygen. It is possible that oxygen has reacted with the planet's surface material but where, then, is the hydrogen? One possible answer is that it may have escaped from the planet back into interplanetary space.

For matter to escape from a planet, whether it be an atom or a spacecraft, its velocity must exceed the planet's escape velocity, about six and a half miles per second for Venus. For a given velocity, the energy of a body is proportional to its mass. Thus, for a given energy, the lighter the atom, the larger the velocity and the greater the probability that it can escape into space. The energy source is the thermal agitation of the atoms at the so-called escape level. This is the altitude, high in the atmosphere, from which an outgoing atom will find no others with which to collide. It is therefore the height from which atoms can escape if they have the necessary velocity. The temperature at Venus's escape level is about 300°K. At this temperature about one hydrogen atom in ten million can exceed the escape velocity and hydrogen can leak away in a period that is short compared with the age of the solar system. For oxygen, however, with sixteen times the atomic mass of hydrogen, the proportion of atoms with the escape velocity is so small that the species is, from our point of view, permanently bound to the planet.

Turning again to Mars, I would like to mention some recent work related to our attempts to understand the subsurface reservoirs of water on that planet. Prior to the *Viking* mission we had measurements from ground-based tele-

scopes indicating that the amount of water in the Martian atmosphere changed rapidly during the day, reaching a maximum at midday. We were able to show that this water could not all condense in the soil but must appear in part in the atmosphere in the form of a ground mist, starting at about 2:00 A.M., and lasting into the morning or possibly until midday. Given the ground-based telescopic results, it appeared inevitable that the *Viking* lander would find itself in a moderately thick mist in the early morning.

As the spacecraft approached the planet, it took pictures of the morning terminator, that is, the dividing line between the unilluminated and illuminated parts of the planet's disk at dawn. One early picture showed the white mists we had anticipated along the terminator. This observation was never repeated, however, and when we eventually managed to have the lander cameras switched on in the morning, the landscape, to our chagrin, was as stark and clear as at any other time of day.

Fortunately, a colleague persevered and, using the lander camera in another mode, was able to show that there was indeed a mist at the predicted times, but that it was ten times thinner than we had predicted. The reason turned out to be a simple one, namely, the ground-based measurements were incorrectly interpreted; what was observed was, in effect, an optical illusion. Our theoretical understanding was sound but the atmosphere contained far less water near the ground than we had expected.

So, one more element fell into place in our understanding of water on Mars. We know something about the evaporation-condensation processes in the polar caps; why the rare ice clouds form as and where they do; and how water condenses in, and evaporates from, the Martian soil. We do not yet know how much subsurface ice there is, how deep it lies, how it flows—if it does—or if there are conditions under which it could have been liquid in some previous epoch. Nevertheless, the puzzle is slowly coming together. □

This article is based on a 1977–78 Sigma Xi National Lecture.



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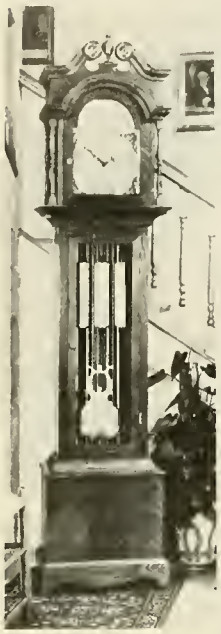
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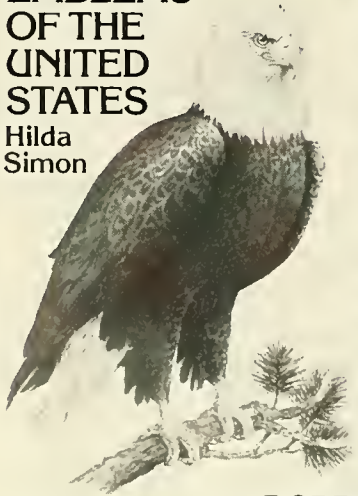
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THE PESTICIDE CONSPIRACY, by Robert van den Bosch. *Doubleday & Co., $8.95; 192 pp.*

"The idyllic world of beetles and butterflies has largely slipped away as I have become increasingly involved in the roaring pesticide controversy; a vicious, nerve-wracking imbroglio that has turned my entomological niche into a veritable hornet's nest," writes Robert van den Bosch in *The Pesticide Conspiracy*. "What is most saddening is that . . . I have turned into a ruthless gut-fighter in a slugfest without rules or a semblance of fair play."

This is a gut-fighter's book, one that will surely offend not only its wide range of targets but also more detached observers in the scientific world. What is one to think of a well-known scientist who salts his text with words like "greed," "rape," "revulsion," and "fools" as freely as other entomologists might use "labium" or "ecdysis"? Indeed, what is one to think of a professor who openly compares the administrators of the great university that shelters him to "a flock of frightened barnyard chickens"?

A van den Bosch could only appear and survive in California, where such elements as its varied history of pest control, the frenetic scramble to peddle chemicals to willing growers, and a state university system geared to accommodate radicals of every stripe produce a highly volatile social mix.

Plagued by pests and chemical salesmen, California cotton growers applied pesticides in excessive dosages. The results were the irruption of new pests and spiraling costs.



Jack Fields, Photo Researchers

by Frank Graham, Jr.

The author is not one of those cultists who shy from any taint of chemicals with the same horror John the Baptist displayed for Salome's charms. "We need pesticides," van den Bosch insists.

But he studied at the University of California under men for whom the triumphs of biological pest control before World War II still shone as both a monument and a promise. He became a specialist at the university in integrated pest control, where chemicals are but one aspect of a complex ecological process that depends on nature to do much of the work, holding pesticides in reserve for the occasional but inevitable moments when natural controls break down. "The insects are their own worst enemies," he writes.

Believing that pest control is a science and a process, van den Bosch watched in disbelief as his discipline fell under the control of those who saw it only as a substance—a chemical whose sale and application would solve all of humanity's pest problems. For van den Bosch, success in dealing with those problems hinges on the outcome of the struggle between the ecologists and the salesmen.

As its title implies, this is a cynical book. Its thesis is that corruption lies everywhere in the pest control field—is, in fact, its very bone and sinew. There are no heroes. Van den Bosch's own discipline is no better than the rest of them, and he quotes without demur a young colleague's definition of an entomologist as "a dumb biologist." He finds the Entomological Society of America rotten with the influence of the chemical companies; its members beguiled by hospitality suites, fishing holidays, and for the more "deserving" among them, industry minigrants.

In this book, chemical salesmen are "rip-off artists," their executives are "Mafia *capi*," agricul-



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tural commissioners are "in collusion" with the salesmen, the United States Department of Agriculture's officials spend most of their energy truckling to politicians who are themselves a part of the "pesticide Mafia," and the land-grant universities are mostly anachronisms whose viewpoint excludes all of society's interests except that of the powerful agribusiness pressure groups.

Well, what about it? Is van den Bosch paranoid or an eco-freak bursting irresponsibly out of academe's closet? The tone is abusive, almost scurrilous at times, but the book's substance is difficult to challenge. This is not a compilation of public records, with an interpretation slapped onto it, but the outcry of a qualified entomologist, with a body of solid work behind him, recounting his experiences and perceptions while carrying out his duties at the University of California at Berkeley.

Although he has made many enemies, van den Bosch maintains a reputation for fierce honesty. If one believes his account of the various meetings and incidents that make up the bulk of this book—and I do—then one must indulge in complicated semantics to characterize the participants as other than he does. Sometimes his attack seems indiscriminate. But on the strength of his firsthand observations, it is apparent that an agreement exists between agribusiness and many public officials to apply chemicals at undiminished levels, whatever the environmental costs, while suppressing scientific evidence that might lead to alternative strategies.

Van den Bosch lays his foundation well. The first part of his book seems to go over some of the ground covered by Rachel Carson, being a recital of pesticide-related disasters, costs, and potential hazards. The point is, however, that nearly all of these incidents have taken place in the years since *Silent Spring* was written, so that its lessons seem to have been absorbed only by people who do not use pesticides in any case. It is sobering to learn that in the United States today we apply more than twice the amount of pesticides that we did in 1962, the year of *Silent Spring*'s publication.

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ence in California, but substantiating it with reports gathered from elsewhere, van den Bosch demonstrates that the excessive use of chemicals has not only failed to solve agriculture's pest problems but has created a host of new ones; insects that were never considered significant pests before have suddenly irrupted in uncontrollable numbers as chemicals wiped out the parasites and predators that previously held them in check. The result is that growers now lose twice as much of their crop as they did in pre-DDT days, although they use twelve times the amount of pesticides, at great cost to themselves and ultimately to consumers.

Greed is the arch villain here. Excessive spraying is built into the politics and economics of the cotton crop, which is plagued by a wide variety of pests. In the past, government subsidies "hooked" growers on the intensive use of chemicals because subsidies were based on average yields—the higher the average yield over a number of years, the higher the subsidy. Growers were thus encouraged to apply chemicals, even at dosages they knew to be uneconomical, for the sake of higher subsidies in the long run.

Van den Bosch, although disapproving of many of the pest control practices he saw around him, attributed them mostly to ignorance until the middle 1960s, when he and other entomologists were commissioned to test the Shell Chemical Company's new product Azodrin® against the cotton bollworm. For three summers he and his colleagues worked on the project. At the end of that time they felt they could not recommend its use.

"At the company's invitation I presented a seminar on our joint Azodrin® study to the Shell research staff," van den Bosch writes. "In this lecture I fully discussed the material's shortcomings and the reasons why the University of California could not recommend it. I thought that this took care of the matter, but how naïve I was: Two seasons later approximately one million acres of California cotton were treated with Azodrin®."

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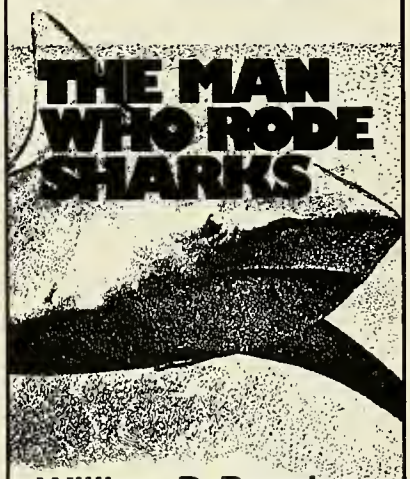
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schedule only when the levels of infestation demanded it, faded quickly. Salesmen, rather than scientists, began to prescribe the treatment for California's pest problems. Billboards, radio commercials, and the editorial pages of farm magazines (dependent on chemical ads for their existence) urged growers to spray early and often. The alternative, the hucksters promised, was ruin.

Instead, van den Bosch watched a number of growers ruined by pests their own gullibility had created and by the resultant spiraling chemical costs. Clearer heads tried to enact legislation requiring the examination and licensing of pest control advisers. The chemical lobby moved in, however, and submitted its own bill under which pesticide salesmen become licensed advisers through an absurdly simple examination.

"Now, when the salesman flashes his business card to a prospective customer," van den Bosch writes, "it bears the impressive title 'Licensed Pest Control Adviser,' and this title is backed by a document bearing the seal of the great state of California. The salesmen are so proud of their newly achieved respectability that they have formed an organization, the Council of California Agricultural Pest Control Advisers."

Van den Bosch recounts a number of incidents when he or his colleagues were harassed by the chemical lobby, politicians, or college administrators. In one such case, the university put obstacles in van den Bosch's path when he tried to fulfill a contract with the Environmental Protection Agency to study the efficacy of "cosmetic spraying" on fruit. This is a wasteful procedure, designed simply to prevent minor blemishes on the peel. The chemical lobby, working through its friends in the university, nearly scuttled the contract. Of the confrontation, van den Bosch writes:

"The contract appears to have been an embarrassment to the University. I regret this, not because it brought me into confrontation with University administration but because it provided a very disturbing insight into the way the University is entangled in agripolitics. On the other hand, it is this sort of thing that reinforces my determination to battle against the cancerous encroachment of such politics into my discipline and into the workings of the University of California and similar institutions."

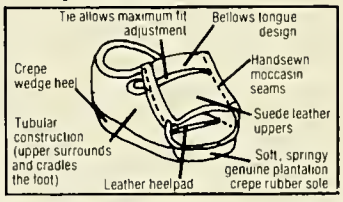
Because van den Bosch has chosen to write subjectively, I would like to have read in just a little more detail about the passion that drove him to study insects in the first place and the day-to-day process of putting together and carrying out an integrated pest control program, since insects, whatever grief they bring us, are fascinating creatures in their own right. But, in this book, van den Bosch does not have his sights on bugs. He is loaded for bigger game, and his blunderbuss inevitably scores many direct hits.

Frank Graham, Jr., a field editor of Audubon, *is the author of a number of books on nature and conservation, including* Since Silent Spring *(1970). His book* The Adirondacks: A Political History *will be published this fall.*



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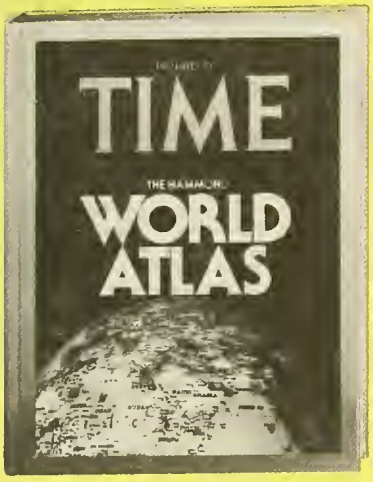
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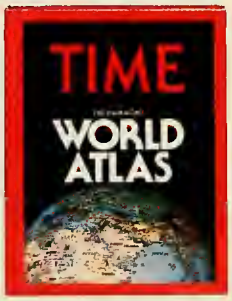


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*The Kola Peninsula: sensitive U.S.S.R. military area, scene of recent encounter between Soviet fighter-interceptors and South Korean airliner.

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***Ouagadougou: Capital of Upper Volta, one of the emergent nations of Africa whose food supplies are menaced by the spread of the Sahara desert.

Sex and the Soybean

To reproduce, the soybean must bloom at exactly the right time

The soybean is not innocent of sex. Unlike higher animals, which carry formed sex organs throughout their lives and use them only sporadically for reproduction, plants make their sex organs, flowers, only shortly before reproducing. Plants form flowers at a time during the annual weather cycle that will guarantee successful production of progeny. Like other, higher plants, the soybean has adopted a variety of biological mechanisms to insure that its flowers form at the right time of year.

For most of its life, the soybean vegetates, producing only roots, stems, and leaves. Through the process of photosynthesis, the plant nourishes itself, making carbohydrate from carbon dioxide in the air and water in the soil, with the aid of sunlight absorbed by chlorophyll and other pigments in bodies called chloroplasts. Each cell of the soybean leaf has between fifty and one hundred of these active green bodies, and the total amount of carbon fixed can be prodigious. By cooperating with *Rhizobium*, a bacterium present in almost all fertile soils, the roots of the soybean plant are able to fix atmospheric nitrogen gas, converting it to ammonia, which then finds its way into amino acids and proteins. This process of nitrogen fixation occurs in nodules, warty protuberances of the root formed after *Rhizobium* cells invade root hairs. Neither the soybean plant nor the bacterium is capable of fixing nitrogen on its own; only the symbiotic association of the two in the nodule makes this process possible.

Each active *Rhizobium* contains a small circle of deoxyribonucleic acid (DNA) in addition to its regular circular chromosome; this smaller circle, called a plasmid, contains the genes for nitrogen fixation *(nif)*, as well as other genes controlling



Bountiful harvests have made the soybean one of the United States most profitable export crops

by Arthur W. Galston

nodule growth. Introduced into the soybean root cell when the bacteria invade through a root hair, the *nif* genes become active and synthesize the enzymes that make nitrogen fixation possible. This tidy cooperation enables the soybean plant to grow independent of nitrogenous fertilizer and even to enrich the nitrogen supply of the soil. So sensitive is the symbiotic nitrogen fixation system that it turns off when nitrogenous fertilizer is added to the soil, as if the plant switches to conserve energy when already fixed nitrogen is available.

With its food assured through photosynthesis and its nitrogen supplied through direct fixation,



Paul Hixon



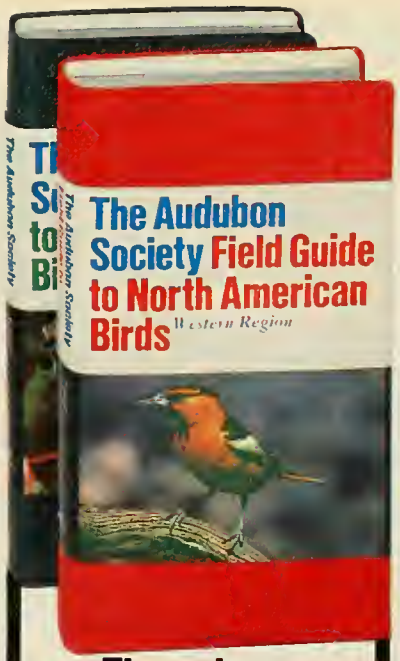
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the soybean plant is well on its way nutritionally. All it needs is water and mineral elements such as potassium and phosphate; these are usually available in a fertile soil or can be easily and inexpensively supplied in fertilizer. These properties, together with a high bean yield, have made the soybean harvest one of America's most bountiful and the soybean one of the most profitable export crops. Virtually nonexistent in the United States in 1940, soybean acreage now about equals that of corn.

But the soybean plant cannot complete its life cycle without a dramatic change from the vegetative habit. The plant is of little use as a crop until it produces beans, and to make beans it must first make flowers. Like all life processes, a plant's transition from the vegetative to the sexual habit—flowering—is genetically determined. Some varieties of soybeans, such as Agate or Batorawka, will flower when they reach a certain age or stage of maturity without relying on environmental conditions. Others, such as Peking or Biloxi, require short days before they can initiate their sexual stage. Each short-day type of soybean has a certain critical photoperiod, a length of day beyond which it will not flower.

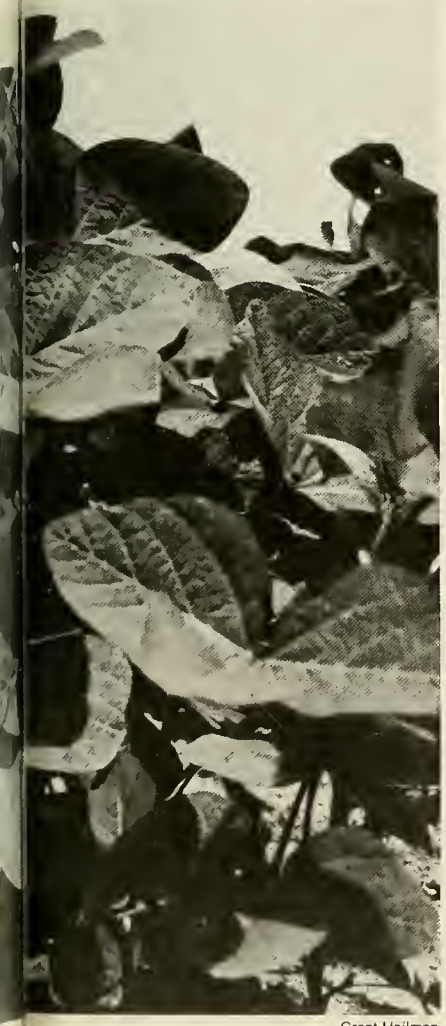
Thus, as the days become progressively shorter in the fall, a date just below the critical day length eventually arrives and the soybean flowers. This photoperiodic requirement insures that the plant will be large and vigorous before it flowers; presumably, it has grown and vegetated from May to August, and now has enough leaves, root nodules, and other vegetative organs to support a large crop of fruit. The date of the photoperiod also guarantees that flowering and fruit-set will be complete before



Rare in 1940, soybeans now occupy nearly as much acreage as corn

the first frost. There are soybean varieties with photoperiods to suit a wide diversity of agricultural regions.

The photoperiodic control of flowering was discovered in the United States in 1920, but despite more than half a century of intensive research all over the world, the intimate biochemical details of the process are still not understood. Since the late 1930s, scientists have known that the soybean uses the dark rather than the light period of the day to measure its photoperiod. Thus, if the critical photoperiod turns out to be fourteen hours, the true control is ten hours of unbroken darkness. The critical dark period is effective whether it is surrounded by four or fourteen hours of light. To some degree, dark-time measurement is controlled by the state of phytochrome, a pigment discovered in 1959 that governs the plant's response to light. When



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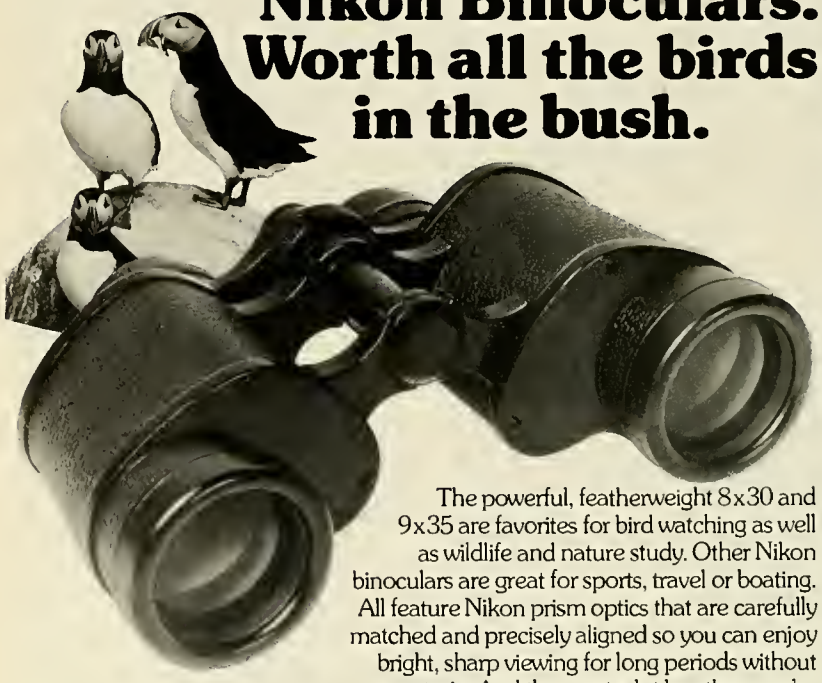
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Night length generally controls flowe

exposed to sunlight, this pigment becomes active; when stored in darkness, it decays back down to its original, or ground level, state. Another component of photoperiodic timing, besides the hourglass scheme of phytochrome activation and decay, is the still-unknown generator of biological rhythms.

Although the buds of the plant change suddenly from producing leaves to forming flowers, the vegetative leaves of the plant, rather than the buds, perceive the photoperiodic stimulus. A short-day Biloxi soybean that has been kept vegetative by exposure to long days can be made to flower by the simple trick of tying a black bag over the leaves for enough hours to add up to an uninterrupted long night of at least the critical length. Even if all

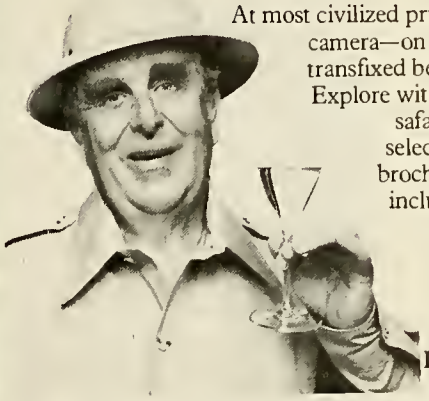


Alan Linn

the plant's leaves except one are trimmed off, exposure of the remaining single leaf to the right photoperiod will result in prompt conversion of the distant bud to the flowering habit. This experiment indicates that some substance formed in the leaf moves to the bud and influences its behavior. This substance, the hypothetical reproductive, or sex, hormone of plants, has been given the name florigen, a hybrid term formed by combining the Latin word for "flower" with the Greek term for "giving rise to."

Simple grafting experiments confirm the existence of florigen. If a flowering plant of Biloxi soybean is grafted onto a vegetative plant that has been maintained on long day, then both the receptor and the donor will develop numerous flower buds. For this experiment

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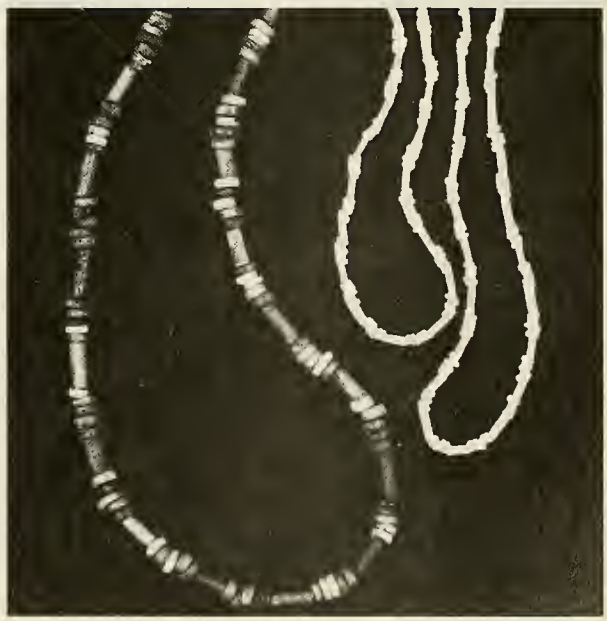
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to succeed, there must be a true union of tissue between donor and receptor, implying that florigen can move only through living cells. By varying the duration of living-cell contact between donor and receptor, the experimenter can calculate that the floral stimulus moves from leaf to bud through the stem at a rate of one to several centimeters per hour, or approximately the rate at which sugar moves through the phloem tissue of the plant's conducting system. If the experiment is done well, then a flowering short-day plant can induce a vegetative long-day plant to flower, and vice versa. Florigen appears to be common to all types of flowering plants.

The graft transmission of florigen is most dramatically displayed



In this electron micrograph of a mesophyll call in a soybean leaf, four chloroplasts lie along the cell's periphery, nearly encircling the large vacuole in the center.

John Burke and William Novitzky

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when only a single induced leaf is grafted from a donor to a receptor plant, the union forming along the diagonally bisected leafstalk, or petiole. This single donor leaf can be effective even if only a small fraction of its leaf blade area remains. The floral hormone must be a very effective compound, since only very tiny quantities of material could move from the small donor leaf tab through the plant to the distant bud.

The sensitivity of the leaf system regulating florigen synthesis is shown by the fact that only a momentary flash of light during the long dark period is enough to completely interrupt the flowering process. This tiny amount of light energy, perceived by phytochrome, is not enough to grossly transform many molecules through direct photochemical effects. Hence, a very little of some effective substance must be affected. Even the intensity of bright moonlight may alter the flowering response, which gives some support to old theories of planting by the light of the full moon. At the next lunar cycle, a long-day plant would be made to flower as a result of the extra bright moonlight, while the flowering of a short-day plant would be prevented or partially inhibited.

One curious bit of quantitative hocus-pocus is especially baffling. Although a few minutes difference in day length—actually night length—can make a complete difference in flowering behavior, one single photoinductive day length is not enough to cause flowering in soybeans, even though it is enough in some other plants. For floral initiation, soybeans require a minimum of four successive short days. If two short days are followed by one long day and then two more short days, the arithmetic is incorrect for the soybean; four correct short days must follow without interruption. Perhaps each successive correct photoperiod leads to the synthesis of a little bit of florigen that is still not enough to cause the plant to change over to the sexual habit; only four correct photoperiods allow the buildup of the required amount of florigen. Perhaps florigen is somewhat unstable, decaying rapidly under unfavorable photoperiodic conditions. If so, then even if three successive photoperiods generated almost enough florigen to initiate flowering, this quantity would all disappear after only one unfavorable photoperiod, and the plant would have to start all over again to receive its four day lengths in a row. Once the critical level of florigen is attained, however, the florigen-producing reaction is self-sustaining.

The physiological evidence for the existence of florigen is so sound that presumably it could be isolated from masses of properly induced leaves, those exposed to the correct photoperiod. But despite many attempts by able investigators over the past forty years, no unambiguous success has been achieved. In the interim, numerous other plant hormones regulating growth—including auxins, gibberellins, cytokinins, abscisic acid, and ethylene—have been isolated and characterized. Why the special difficulty with florigen? There are several possible answers: florigen may be difficult to extract, unstable once extracted, or difficult to reintroduce properly. Again, florigen may not be a single sub-

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stance, like the other hormones, but a mixture of substances that are separated from each other in the leaf extract during the purification procedure. Florigen transport does seem to follow sugar-transport patterns in the plant, and the negative effects of noninduced leaves (not given a photoperiod that leads to flowering) are manifest only if they are located between the florigen-producing leaves and the bud to be influenced. Therefore sucrose, the major transport sugar of plants, could have an influence on flowering habit. In some plants that have remained vegetative because of incorrect photoperiod, simple defoliation can cause flowers to appear. The leaves may have inhibited flowering because their export of sucrose to the bud blocked the transport of florigen to an induced leaf.

The hunt for florigenically active chemicals proceeds in many laboratories, partly because of the potential practical importance of such substances. At present, pineapples can be chemically induced to flower by ethylene or ethylene-generating systems. Similarly, gibberellins can induce some long-day plants to flower. In tissue culture experiments, sucrose is sometimes an important factor in the appearance of flower buds. But the true nature of elusive, transmissible, universally active florigen remains mysterious.

Arthur W. Galston teaches biology at Yale University.

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Deep in the Heart of the Milky Way

New discoveries are being made about an energetic source of radio emissions in the region of Sagittarius

Radio astronomers exploring the central region of our Milky Way galaxy have discovered an unusual source of radio waves. Because of the thick dust clouds that lie between the earth and the galactic center, the source cannot be seen or photographed in visible light. Hence the theories that have been proposed to explain the source are speculative at best.

The Milky Way is a spiral galaxy, a vast, pinwheel-shaped system of several hundred billion stars, which also includes nebulae, star clusters, and interstellar gas and dust. The earth is situated in one of the arms of the pinwheel, at a distance of about 33,000 light-years from the center. If we were situated high "above" the pinwheel, we would be able to look down at its center with an unobstructed view. Since that is not possible, most of what we have learned until now about the central regions of galaxies has come from looking away from our own pinwheel toward other galaxies located millions of light-years away.

Optical telescopes and radiotelescopes have shown that in many cases these galaxies have a bright point at their centers, where stars are strongly concentrated and where powerful radio emissions are



Robert L. Brown, National Radio Astronomy Observatory

by Stephen P. Maran

generated. Such tiny, energetic regions are known as galactic nuclei. Not all galaxies have them, and it is not clear whether the unusual radio source at the center of the Milky Way is a related object.

For many years astronomers have known that the center of the Milky Way is in the direction of the constellation Sagittarius. Early radiotelescope studies showed, more specifically, that the center lies in the direction of a fairly large radio source known as Sagittarius A. When improved equipment allowed radio observers to map Sagittarius A in greater detail, the radio source was found to consist of several smaller sources that are not necessarily related to each other. The location of the center was narrowed down to a small region of radio emission within Sagittarius A that is known as Sagittarius A West, or "Sgr A West" for short. Since 1974, marked progress in the study of this region has been made through the application of several variations of an experimental technique known as radio interferometry.

Put simply, radio interferometry consists of observations made with

The small radio source at the nucleus of the Milky Way is the red spot on the right side of this computer-produced diagram. The yellow spots around the source are ionized hydrogen nebulae. The blue spot and the diagonal bands are secondary recordings of instrumental origin. The colors correspond to different intensities of radio waves. The diagram is based on measurements made with the giant new interferometer near Socorro, New Mexico.



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two or more radiotelescopes that are pointed simultaneously at the same spot in the sky. The signals received by the individual telescopes are electronically combined to produce the desired measurements. The primary purpose of radio interferometry is to reveal finer details than those discernible with a single radiotelescope.

Interferometry, in effect, provides a "higher resolution," or sharper "view," of celestial radio sources than otherwise possible. For observations at a given radio wavelength, the larger the radiotelescope, the higher the resolution. However, even the world's largest single-dish radiotelescope, the 1,000-foot "Big Ear" at Arecibo, Puerto Rico, provides only very coarse resolution as compared with the fine celestial details that can be photographed with very small visible-light telescopes, such as those sometimes advertised in the pages of this magazine.

An interferometer consisting of two ordinary, 85-foot-diameter, dish-shaped radiotelescopes located five miles apart, for example, will provide twenty-six times higher resolution than Arecibo's Big Ear. In fact, such an interferometer achieves a resolution equal to that of a dish antenna five miles in diameter. In other respects, the interferometer is no match for a five-mile-diameter dish, but that kind of dish is beyond present technology and financial limitations.

Generally speaking, the greater the separation between the respective antennas of an interferometer, the higher the resolution that can be attained with it. Some interferometers consist of antennas located at opposite ends of the United States, as in the teaming up of a

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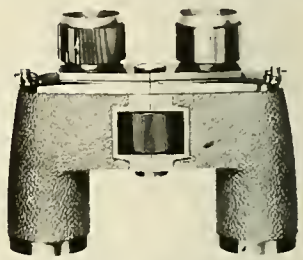
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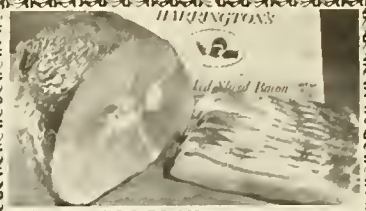
radiotelescope at Westford, Massachusetts, with one at the Jet Propulsion Laboratory's tracking station in Goldstone, California, or even antennas on opposite sides of the earth, as when the United States and the Soviet Union use their respective radiotelescopes on a common study.

The existence of a tiny radio source at the center of the Milky Way was discovered in February 1974, when astronomers Bruce Balick, of the University of California, Santa Cruz, and Robert L. Brown, of the National Radio Astronomy Observatory in Green Bank, West Virginia, used a new radio interferometer to observe Sgr A West. The small source they found within Sgr A West had a diameter of less than 1,000 astronomical units.

One astronomical unit (AU) equals the average distance from the earth to the sun—about 93 million miles. A size of 1,000 AU may thus sound large, but in fact it is small by the usual standards of the radio astronomer. Distant radio sources are frequently measured in light-year units, that is, the distance that light travels through space in a period of one year—about 5.8 trillion miles. The size of the galactic nucleus source, as the Balick-Brown radio source has come to be called, is less than the distance light travels in one week. Their measurements indicated, furthermore, that a more powerful interferometer was required in order to see just how small the source really is.

In May 1975, a more powerful technique, known as VLBI (Very Long Baseline Interferometry) was applied to the galactic nucleus source by four observers from CalTech, led by K.Y. Lo. In the VLBI technique, observations are made with radiotelescopes so far apart that a radio link may not perform satisfactorily. The signals received by each antenna are therefore recorded on magnetic tape at the antenna site, along with precise information on the time at which the signals are received. After the observations are completed, the data on the tapes are combined in an electronic computer, and the timing data are used to insure that signals recorded simultaneously are properly combined.

Lo's team used two California



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antennas, one of 130-foot diameter at the Owens Valley Radio Observatory near Mount Whitney and another of 210-foot diameter located about 150 miles away at the Jet Propulsion Laboratory's Goldstone tracking station. With these antennas, the observers found that the nucleus source was at least five times smaller than the size estimated by Balick and Brown. Specifically, they discovered that the source's diameter is no more than 200 AU, or only about two and one-half times the diameter of Pluto's orbit around the sun.

A real breakthrough in understanding the galactic nucleus source came in 1976, when three radio astronomers from the University of Manchester reported an elaborate study made at three radio wavelengths with three different interferometers. The Manchester team discovered that the diameter of the nucleus radio source seems to depend on the wavelength at which it is observed. They found further that the measured diameters follow a so-called wavelength squared law, meaning that if the diameter is measured first at one wavelength and then at another that is, say, two times longer, the second diameter will be four times as large as the first one. If a measurement is then made at a third wavelength that is three times as long as the first one, the observed diameter will be nine times as great.

The Manchester astronomers pointed out that when radio waves travel through an ionized region—a part of space filled by gas that is electrified and heated by the action of ultraviolet light from hot stars—they are disturbed by the presence of turbulent clumps and irregularities in the distribution of the ionized matter. The net effect is to smear out the waves, so that a small radio source will appear larger than its true size as perceived by a distant observer.

This process, called interstellar scattering, is analogous to the smearing effect of turbulent air in the earth's atmosphere on the passage of light waves from the stars. When examined at high magnification in a large telescope, the images of stars are found to be blurred by this effect, so that they resemble patches of light instead of tiny points. Thus, the Manchester team concluded that the true size of the galactic nucleus source was smaller than indicated by previous observations. In particular, they estimated the true size of the source was about 100 AU, or half as large as the value suggested by the CalTech group in 1975.

The Manchester team was correct in concluding that the galactic nucleus source was smaller than indicated by the available observations, but their estimate of 100 AU was still too large.

The next major study, by four scientists at the National Radio Astronomy Observatory, showed that the source contained a bright central core with a diameter of only 10 AU, about equal to the diameter of Jupiter's orbit around the sun. Using a transcontinental interferometry system, the NRAO observers found that the galactic nucleus source consists of the bright core of 10 AU in size, surrounded by a radio wave "halo" of about 100–200 AU.

According to a later interpretation of the transcontinental interferometry results, the core and halo

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of the radio source can be compared to the appearance of the full moon when observed through a layer of thin clouds. The moon is then seen as a bright object surrounded by a fainter, but much larger, halo caused by the action of ice crystals and water drops in the clouds scattering, or reflecting, the moonlight. Thus, the core of the observed radio source is the true source and its observed size corresponds to the intrinsic size of the object, while the halo consists of radio waves that have been scattered by the intervening ionized gas.

The Manchester scientists assumed that the observed interstellar broadening was produced by ionized regions located along the line of sight between the earth and the galactic nucleus. A recent analysis of available observations at all wavelengths, however, shows that the zone in which the broadening occurs must actually lie at the far end of the line of sight from the earth, close to the nucleus. This analysis by Donald C. Backer of the University of California, Berkeley, a world authority on interstellar scattering, shows that the region where the radio waves are scattered must be within about 300 light-years of the nucleus and must consist of turbulent clumps of ionized gas with an average size of not much more than a half mile.

The latest findings on the galactic nucleus source appear to confirm Backer's analysis and to place the region of broadening precisely at the end of the line of sight to the nucleus. The findings, which were reported this year by Brown and Lo, together with Kenneth Johnston of the Naval Research Laboratory in Washington, D.C., are based on measurements made with a giant interferometer still under construction on the Plains of San Agustin, west of Socorro, New Mexico, but already in partial operation. According to these results, the radio source is actually immersed in a dense zone of ionized gas, with properties consistent with those deduced by Backer as necessary to produce the observed broadening. Thus the broadening occurs in the immediate surroundings of, or even coextensively with, the galactic nucleus source itself.

The broadening of the galactic nucleus source as observed with radio interferometers from Earth has now been explained. But the nature of the source itself remains in doubt. It differs in certain marked ways from the nuclei of other galaxies that also show intense radio emissions. In particular, the total radio energy from the nucleus of the Milky Way is much less than that produced in nuclear sources of other galaxies, but the amount of energy produced per unit volume of space is actually higher. Speculation that the source is a young supernova, a pulsar, a giant black hole, or an unusual binary star remains unconfirmed. Fortunately, since the nuclear source was discovered less than five years ago, many avenues of investigation remain open and surely further study will unlock at least some of the secrets at the heart of the Milky Way.

Stephen P. Maran is senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

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Celestial Events

by Thomas D. Nicholson

Sun and Moon The sun is barely past the autumnal equinox at the beginning of October, in the part of the ecliptic (its apparent path on the sky) where it is moving southward most rapidly. It will be in the constellation Virgo for the whole month, moving into Libra at the beginning of November. In Virgo, the sun moves steadily south until, by the end of the month, it is more than halfway from the equatorial plane to its most southerly position. The effect will be clearly noticeable in the shortening periods of daylight.

An evening moon appears in the first week of October and again in November, getting larger and brighter and remaining visible later each night until full moon about midmonth. In the last half of October and November, the moon wanes, rising later at night and setting later during daylight. In October, new moon is on the 2nd, first-quarter on the 9th, full moon on the 16th, and last-quarter on the 23rd. Another new moon occurs on October 31, and in November the first-quarter moon is on the 7th, full on the 14th.

Stars and Planets Although Venus is at greatest brilliancy early in October, it is not well placed as an evening star. Mars and Mercury, also evening planets, are too low to be seen. The best planets this fall are Jupiter and Saturn, both morning stars. Jupiter rises about midnight, a very bright object between the Gemini (the twin stars Pollux and Castor), which rise earlier, and Regulus (in Leo), which rises later. Toward morning, Saturn will also enter the sky, rising after Regulus, and appearing well up in the southeast at dawn.

October 3: Venus reaches greatest brilliancy as an evening star. It has been brightening as it approaches the earth before moving in between the earth and the sun. But it is also turning its sunlit face away from the earth, causing it to become dimmer in the weeks ahead as it approaches the end of its cycle as an evening star.

October 4: If the western sky is clear after sundown, look for Venus below and to the right of the crescent moon.

October 16: The full moon this month is known as the hunter's moon. Its position and path cause bright moonlight to be available during the early evening for several nights in succession.

October 17: Venus becomes stationary relative to the stars and begins to move westward as it passes between the earth and the sun.

October 21: The Orionid meteor shower reaches maximum. Although not very productive (up to 25 per hour at maximum), its meteors are often swift and bright.

October 24–25: Jupiter is the bright object near the waning moon from midnight until dawn.

October 27: Saturn is the object near the crescent moon in the east at dawn this morning. Jupiter is higher and brighter and to the right.

November 4: The Taurid meteors reach maximum, but they are sparse, brief, and dim.

November 7: Venus, at inferior conjunction, becomes a morning star.

November 15: The moon covers the bright star Aldebaran beginning at about 10:00 P.M. and ending about 11:30 P.M., EST (times vary with location). The event will be visible throughout North America, but binoculars will be necessary to see Aldebaran when it is near the edge of the bright full moon.

★ Hold the Star Map so the compass direction you face is at the bottom, then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:15 P.M. on October 1; 10:20 P.M. on October 15; 9:15 P.M. on October 30; and 8:20 P.M. on November 15; but it can also be used for an hour before and after those times.





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Additional Reading

Prairie Dogs (p. 56)

In *Must They Die: The Strange Case of the Prairie Dog and the Black-Footed Ferret* (Garden City: Doubleday and Co., 1971), Faith McNulty vividly describes the horrors and politics of the government-enforced program of predator and rodent control, which has further reduced in number the nearly extinct black-footed ferret. Two books by David F. Costello cover the characteristics, behavior, and ecological role of the prairie dog: *The World of the Prairie Dog* (Philadelphia: J.B. Lippincott Co., 1970) and *The Prairie World* (New York: Thomas Y. Crowell Co., 1969). A classic scientific study by John A. King, "Social Behavior, Social Organization and Population Dynamics in a Black-tailed Prairie-dog Town in the Black Hills of South Dakota," can be found in *Contributions from the Laboratory of Vertebrate Biology of the University of Michigan* (no. 67, April 1975, pp. 1–123). Carl B. Koford's "Prairie Dogs, Whitefaces and Blue Grama," another scientific account, was published by the Wildlife Society (*Wildlife Monographs*, no. 3, December 1958). A short but detailed description, "Burrow Systems of Prairie Dogs in South Dakota," by R. G. Sheets, R. L. Linder, and R. B. Dahlgren, appeared in the May 1971 *Journal of Mammalogy*, pp. 451–53. *Prairie Dog Town*, by Margaret Thomsen Raymond and Carl O. Mohr (New York: Dodd, Mead and Co., 1952), is a natural history for children, with drawings and photos.

Canelos Quichua Ceramics (p. 90)

To study the subject in greater depth, see *Sacha Runa: Ethnicity and Adaptation of Ecuadorian Jungle Quichua* (Urbana: University of Illinois Press, 1976), written by Norman E. Whitten, Jr., with the assistance of Marcelo F. Naranjo, Marcelo Santi Simbaña, and Dorothea S. Whitten. *The Upper Amazon*, by Donald W. Lathrap (New York: Praeger Publishers, 1970), studies people of the Upper Amazon Basin, emphasizing their migrations and cultural development; the book is illustrated and has a bibliography. Ethnographic data in *The Jívaro: People of the Sacred Waterfalls* (Garden City: Doubleday/Natural History Press, 1972) were gathered in the field by the author, Michael J. Harner. His book is a broad introduction to the culture of a people who in the years 1956–57 did not yet have regular contact with whites. Other books, which may be somewhat hard to find, are *Sarayacu Quichua Pottery*, by Patricia Kelley and Carolyn Orr (Dallas: Summer Institute of Linguistics, publication no. 1, 1977), and *The Geological Imperative: Anthropology and Development in the Amazon Basin of South America*, by Shelton H. Davis and Robert O. Mathews (Cambridge: Anthropological Resource Center, 1976).

Owl Hunt (p. 100)

The Magic of Owls, by Jozefa Stuart (New York: Walker and Co., 1977), is a beautifully illustrated paperback of owl art through the ages. It includes French cave art from 35,000 years ago; owls from the Chou Dynasty of China, 3,000 years ago; Egyptian pieces; Eskimo carvings; and much more. Brian Stone's translation of *The Owl and the Nightingale*, the twelfth-century Old English poem quoted in "An Owl Hunt," was published as a paperback by Penguin Publishing Company in 1972. *The Bestiary: A Book of Beasts*, by Terence H. White (New York: G. P. Putman's Sons, 1960), is an illustrated translation, with commentary, of a twelfth-century bestiary. An entertaining and informative book, *Birds, Beasts, and Men: A Humanist History of Zoology*, by H. R. Hays (Baltimore: Penguin Books Inc., 1973), has a section on the Middle Ages and a bibliography. Tony Angell's *Owls* (Seattle: University of Washington Press, 1974) is a large, colorful natural history. Its biology is sound and it too has a bibliography. Another illustrated book, *Owls: Their Natural and Unnatural History*, by John Sparks and Tony Soper (New York: Taplinger Publishing Co., 1970), devotes a chapter to owl lore.

Ice Age Art (p. 108)

The Abbé Henri Breuil was one of the most distinguished scholars of Upper Paleolithic art. His *Four Hundred Centuries of Cave Art* (Montignac: Centre d'Etudes et de Documentation Prehistoriques, 1952) is recommended to anyone interested in the subject. Alexander Marshack, a leading authority on the Upper Paleolithic period, was a scientific consultant for the American Museum of Natural History's **Ice Age Art** exhibit, which will run through mid-January 1979. His *The Roots of Civilization: The Cognitive Beginnings of Man's First*

Art, Symbol and Notation (New York: McGraw-Hill Book Co., 1972) analyzes engravings, *mobiliers* and other carvings, and cave paintings. This large book has an annotated bibliography. *Palaeolithic Cave Art*, by Peter J. Ucko and Andrée Rosenfeld (New York: McGraw-Hill Book Co., 1967), is an illustrated critique of some of the theories of the origin of cave art. Magín Berenguer gives a personal account of one discovery of cave paintings and discusses the controversies concerning the authenticity of Altamira in *Prehistoric Man and His Art: The Caves of Ribadesella* (Park Ridge: Noyes Press, 1975). *The Threshold of Civilization*, by Walter A. Fairservis, Jr. (New York: Charles Scribner's Sons, 1975), is an illustrated interpretation of Ice Age artifacts found in Turkey, Czechoslovakia, and the French Riviera. In this book, which includes drawings, diagrams, and a bibliography, Fairservis offers an analysis of the evolutionary development of human cultures into civilizations.

Katharine D'Agosta

ERRATA: The August–September 1978 issue contains two inaccurate captions. The plant in the lower right-hand corner on page 66 of "The Decline of Lake Plants" is an arrow arum, not an arrowhead. In "The Salmon May Make It," the fish under attack by the lamprey on page 85 is a rainbow, not a lake, trout.

Fermentation: The miracle that turns the juice of the grape into wine.



Although it is an oft-proclaimed truth that fine wine is a living, growing thing, nowhere is this more evident than during that critical, and still somewhat mysterious, process called fermentation.

Yeast: The Catalyst

It is possible that a quantity of fine grapes crushed and left to themselves in an open container will, in time, ferment and yield an acceptable wine.

It is probable, however, that these same grapes will yield a wine not so pleasant.

Which it will become depends in large measure on the vagaries of simple, one-celled plants called yeasts which are found naturally in the bloom on the skins of grapes.

A Louis Pasteur Discovery

Until 1864, wine-making was a matter of uncertainty. But then Louis Pasteur discovered that these yeasts were, indeed, the agents that caused fermentation.

Equally important, he discovered that specific strains with desirable characteristics could be isolated and substituted for the wild yeast in the wine-making process, a major step toward predictable excellence.

Today, our winemakers are devoted to the study of yeasts and to their improvement. Because no one yeast works equally well in every case, we are constantly striving to isolate the ideal yeast for the different varieties of wines.

This development of the specific yeast which maximizes a grape's natural flavor potential is a primary study we have pursued for years.

To achieve a wine of predictable excellence year after year, we developed the first successful dehydration of pure wine yeast. The dehydrated form maintains the consistent purity from year to year and provides us with a "cleaner" wine that is truer in flavor and fragrance to the grape.

Some Like It Cold

During fermentation, heat is created. If we permit the fermenting juice or "must" to attain a temperature of only ninety degrees, the yeast can be injured. At one-hundred degrees, most yeast will die.

Over the years, we have developed precise cooling methods for keeping the fermenting liquid at the optimum lower temperature. This varies from grape to grape. For example, the Sauvignon Blanc, French Colombard, Chenin Blanc, Riesling or Chardonnay we use for our white wines are far more delicate and sensitive to temperature than their more robust red cousins.

We determined that fermenting them at a cooler temperature slows the change from juice to wine and results in protecting the delicacy of the resultant wine.

In this cooled state, the juice can ferment as long as fourteen days rather than three or four.

The Test Fermentation

Knowing the precise moment to draw the wine is a combination of the skill and art of our winemakers.

In some cases we actually take grape samples a few days before harvest and, on a small scale, proceed with fermentation. This gives us a preview of what to expect, and, we then make whatever adjustments necessary to produce the most consistently excellent wine.

Our Purpose

The precise control of fermentation is but one of the many steps which our winemakers have mastered in order to achieve our goal. Here at the winery of Ernest and Julio Gallo, our purpose is to bring you the finest wine that skill and care can produce.

Ernest and Julio Gallo, Modesto, California

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At the Museum

Visitors who came to see anthropological films at the Margaret Mead Film Festival in early September left with some idea of the Museum's connection with New Guinea. The 1978 festival included Mead's and Gregory Bateson's *Bathing Babies in Three Cultures*, in which one bathing sequence takes place in New Guinea's Sepik River. Another festival offering, Jean Rouch's film portrait of Margaret Mead, shows Mead walking through the Hall of the Peoples of the Pacific, which is currently being moved and reinstalled under her direction. She conceived the idea of the hall in 1928 and began working seriously on the project in 1946. The hall, devoted to the peoples of Indonesia, the Philippines, Australia, Melanesia, Polynesia, and Micronesia, first opened in 1971 and held a fraction of the Museum's Oceanic collection.

Ornithologists, mammologists, and herpetologists from the Museum have made expeditions to New Guinea, and Mead herself has worked with three tribes—the Manus, the Mountain Arapesh, and the Mundugumur. "In December 1931," she recalls in her autobiography, *Blackberry Winter*, "we came to Arapesh and began the fieldwork that was to give me a completely new insight into the nature of sex roles in culture and into the ways in which innate differences of temperament and culture are related."

The fruits of Mead's labors on the Hall of the Peoples of the Pacific cannot be appreciated before 1980, when the hall will reopen. Meanwhile, in Gallery 77 on the Museum's first floor, **Papua New Guinea: Then and Now**, a special exhibit on view through mid-October, describes one part of the South Seas.

This exhibit honors the third anniversary of the political independence of Papua New Guinea, which comprises the eastern half of the island of New Guinea, as well as six hundred offshore islands in the western corner of the South Pacific. Papua New Guinea is home to more than a thousand tribes, most of which still lead rural, village lives. According to Paulias Nguna Matane, Ambassador to the United States and Permanent Representative of Papua New Guinea to the United Nations, the point of the exhibit of artifacts, slides of flora and fauna, and tapes of birdsong and music is to give Westerners some knowledge of Papua New Guinea beyond what they remember from World War II or *South Pacific*. Matane was pleased to find that his home region is already depicted in a diorama in the Museum's Hall of Oceanic Birds.

Exhibit visitors who want to study Papua New Guinea will see enormous carved wooden figures, tapa cloth made from bark, musical instruments, headdresses, masks, jewelry, and craftwork. They can stand inside a full-size replica of a conical, thatched roundhouse, the traditional home of some Papuan Highlanders. And they can learn about the importance of the sea to local tribes by inspecting an outrigger canoe from the Papuan coast or a *lagatoi*, a double-hulled canoe with a hand-stitched sail of banana leaves.

Beginning the last week of September, there will be nine performances in the auditorium, free with Museum admission, of traditional music, drama, and dance from Papua New Guinea. The performers will be the Raun Raun Theatre Company, presenting drama from the Highlands; the Mekeo Dancers from the coast, who, wearing five-foot feather headdresses, dramatize folk tales; and the Asaro Mudmen, ghostly figures in clay masks, from the eastern Highlands. The performances in October will take place on Sunday, October 1, at 2:00 P.M. and Wednesday, October 4, at 7:00 P.M.

Other Events

On Sunday, October 8, at 3:00 P.M. in the auditorium, the **Big Drum Nation Dance Company** will present a program of ritual dance and drumming from Carriacou. On festive occasions, the people of this small Caribbean island may drum, dance, and sing until sunrise. Tickets are $4 for Associate Members and the public. Participating, Donor, and Life Members may purchase up to six tickets at the special price of two tickets for the price of one. For further information, call the Membership Office at (212) 873-1327.

On Wednesday evening, October 18, at 7:30 P.M. in the auditorium, **Howard Topoff** of the Museum's Department of Animal Behavior will lecture on "Army Ants: Huns and Tartars of the Insect World." Topoff, who was the curator in charge of the Museum's 1974 exhibit of a colony of 500,000 ants, will discuss the behavior of these insects, beloved of science fiction film and story. Admission will be free to Participating, Donor, and Life Members; $2 for Associate Members and the public.

Last winter, **Stephen Jay Gould** published *Ever Since Darwin* (New York: W. W. Norton and Co.), a collection of essays that he has written since 1974 for his *Natural History* column, "This View of Life." Gould lectures as felicitously as he writes, with a fine sense of theater as well as scientific history. At Rockefeller University in New York, he opened a talk on evolutionary theory by showing a Steinberg drawing of the tree of evolution, topped by the American eagle. Gould followed up with a nineteenth-century engraving of the tree of life, complete with bark, leaves, and branches heavily weighted with various species. On November 15, at 7:30 P.M., Gould will give an equally entertaining and knowledgeable lecture in the Museum's auditorium. Admission will be free to Participating, Donor, and Life Members; $2 for Associate Members and the public.

Ann Marie Cunningham



"This is reclaimed land. The coal is out, and soon the sheep will be grazing here again."

"We need the land as much as we need the coal. We found a way to have both."

"For centuries, the Navajo have used this land for grazing their sheep," says Ben Sorrell, a Gulf Land Reclamation Supervisor. "Their whole livelihood depends on it, as it has for centuries.

Riches below

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"Now it's one of P&M's most productive mines. It's producing three million tons of coal a year, and it's being expanded to five million.

Riches above

"It's my job to put things back pretty much the way they were before mining started.

"As much as possible, we try to restore the character of the land, the general contours, and especially the drainage patterns.

"When we're finished, it's as good grazing land as it ever was—sometimes better.

"It's a real challenge, getting out the coal we need, without destroying the land, which we need just as much. I'm a Navajo myself, and I'm proud of the way Gulf is meeting that challenge."



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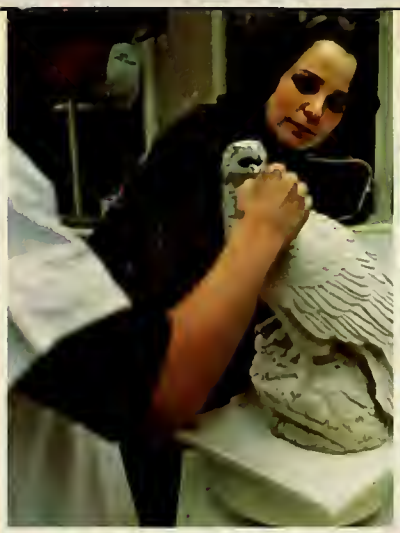
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Cover: *A Mekranoti Indian child of central Brazil wears shell jewelry for a festival that ends one of his village's long jungle treks. Photograph by Dennis Werner. Story on page 42.*

Authors

A field correspondent for *Defenders* and staff writer for *Pacific Search*, **Delphine Haley** also does free-lance writing and editing. She has concentrated on North American wildlife and marine mammals and is editor of *Marine Mammals of Eastern North Pacific and Arctic Waters*, from which the Steller's sea cow article is adapted. Of her interest in doing the book, she writes, "with the first name Delphine, and some whaling ancestors to jog the genetic memory, it seemed like a natural project to undertake." Haley divides her time between a houseboat in Seattle and a log cabin on a small, unspecified island in British Columbia.





Dennis Werner is holding a belt rattle of peccary hoofs, made by the Mekranoti Indians who live in the Amazon forest in central Brazil. Of the eight weeks he spent trekking with the Mekranoti, he reports, "I was a bit disappointed that I had to eat garden produce; I had hoped for meals of exotic fruits and wild roots." After spending more than a year in Brazil, Werner is now a doctoral candidate at the Graduate Center of the City University of New York and an adjunct lecturer at Hunter College. Like many of his colleagues, he is interested in both science and music. In his free time he plays the harpsichord.

Because he is both a herpetologist and a physician, **Sherman A. Minton, Jr.**, probably hears about freakish snakebites more than most professionals. A virtual subspecialty of his is snakes that have bitten other herpetologists. (He sends no information as to whether he himself has ever been bitten.) A professor of microbiology at the Indiana University School of Medicine, Minton has been doing research on the serological relationships of snakes, particularly venomous species; the neutralizing abilities of antivenins; and the human influence on the distribution of amphibians and reptiles. Before assuming his post at Indiana, he was professor of microbiology at the Jinnah Postgraduate Medical Center in Karachi, Pakistan.



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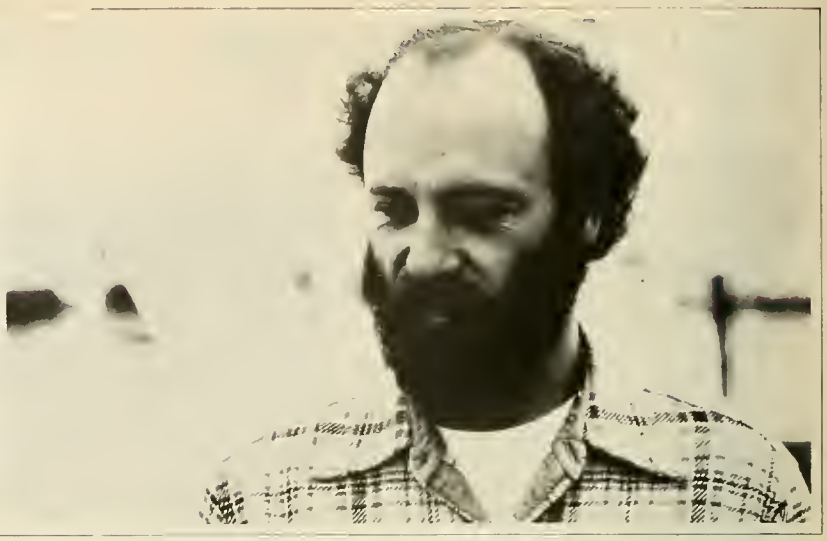
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In the course of researching his Ph.D. dissertation on a California fishing community, **Jack Stuster** found that he did not understand any of the radio messages transmitted by the fishermen. His curiosity about the significance of the transmissions led to his article in this issue on communication in West Coast fishing fleets. An anthropologist with a consulting firm in San Francisco, Stuster earned his degrees at the University of California, Santa Barbara. His interest in fishing is not limited to academic study; he helped organize and then managed a cooperative fish market in Santa Barbara during the time he wrote his dissertation.





While writing a book on the evolution of fever and investigating whether a high temperature helps an infected organism to survive, **Matthew J. Kluger** began reading up on Hippocrates' theories of fever therapy and the related practice of bloodletting. Associate professor of physiology at the University of Michigan Medical School, Kluger continues to investigate the relation between body temperature and immune response. He has already described some of his findings in *Natural History* ("The Importance of Being Feverish," January 1976). When he is not studying the history of biology and medicine, Kluger keeps his blood pressure down by playing basketball and running—his maximum so far is fifteen miles.

Setting out to study the breeding habits of sandhill cranes, a project that extended over three summers in Jackson Hole, Wyoming, **Paul A. Johnsgard** eventually became more enamored of the area's trumpeter swans than the sandhills. In addition to making field observations of trumpeters, sandhills, and other bird species, Johnsgard serves as professor of zoology at the University of Nebraska and also churns out books. He is currently working on two ornithological tomes: one, to be published next year, on the breeding birds of the Great Plains states; the other, on which he is just getting started, will be on the shorebirds of the world. His last article for *Natural History*, "Flight of the Sea Ducks," appeared in the August-September 1976 issue.





Main intersection at a Hollywood oil field.

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"One of the strangest places I ever produced oil," says Gulf Production Superintendent Eddie Culbertson, "was right here in Los Angeles, in the back lot of the 20th Century-Fox studio.

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"Sometimes it's a real challenge getting the oil without spoiling the landscape. Directional drilling is one way to do it. There are many more.

"Getting the oil out and preserving the environment is a challenge, but I'd say we were meeting it very well."

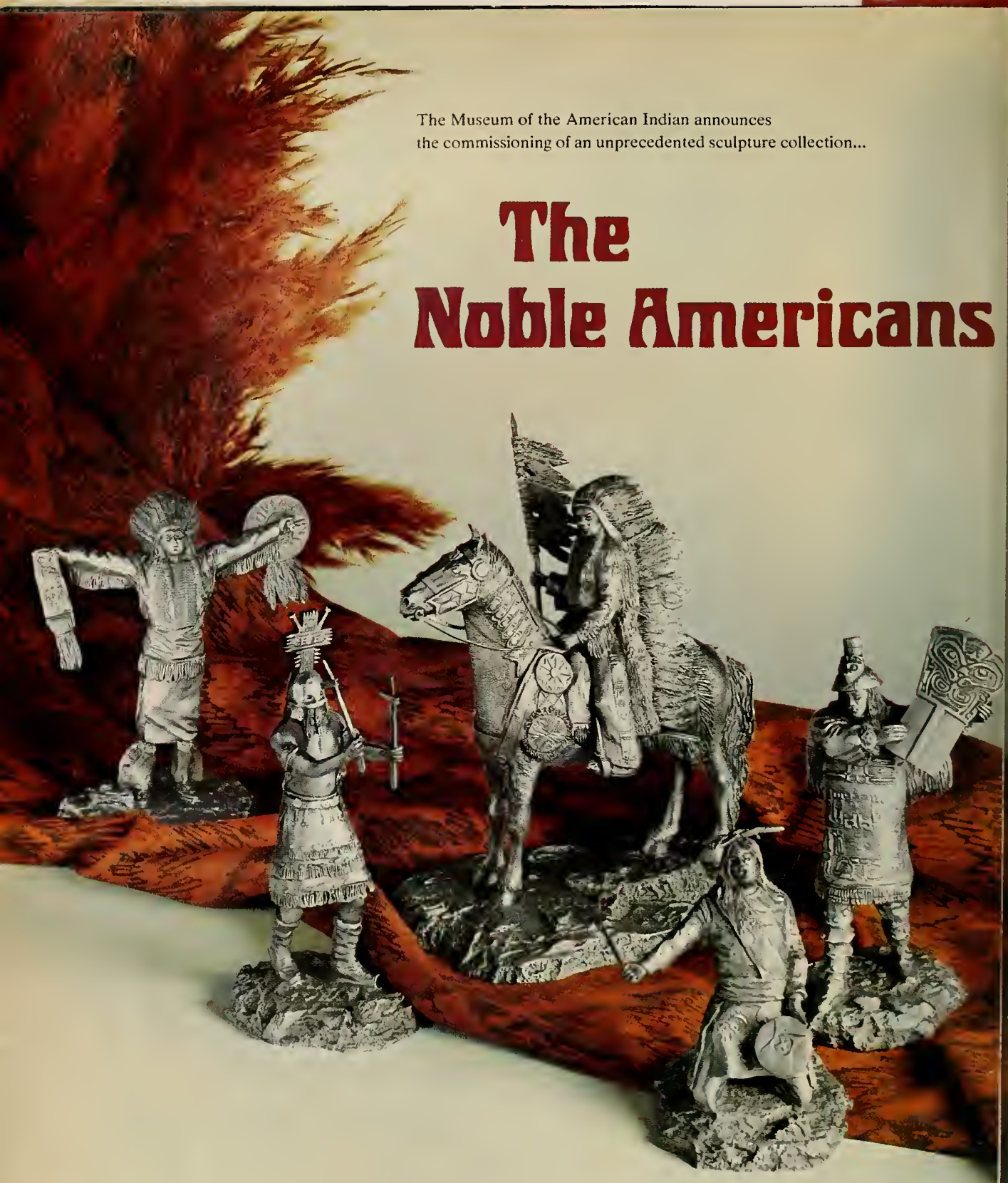
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The Noble Americans



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The complete collection will consist of 12 full-figure pewter sculptures, each a work of art in its own right, portraying the majestic Indian men and women who once ruled this land.

Iroquois...Seminole...Pawnee...Sioux...Blackfoot...Mandan...Navajo...Arapaho...Hopi...Tlingit...Chippewa...Apache. The ringing names of the American Indian tribal nations are today well-known all over the world. But the images behind the names are less familiar. And in 'The Noble Americans' collection, American Indian men and women will be revealed to us as real people—just as they might have been seen in tribal life and ceremonial rituals, long ago.

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Saga of Steller's Sea Cow

by Delphine Haley

The largest sea mammal of its kind was last reliably seen in 1768. Some sketchy Soviet sightings suggest it survives

The Steller's sea cow is the only North Pacific sea mammal to become extinct in historical times. Discovered in the winter of 1741–42, when explorer Vitus Bering's crew was shipwrecked on an island that would later bear their leader's name, this giant marine herbivore was literally devoured into oblivion because of its beeflike meat and sweet-tasting blubber. For twenty-seven years following its discovery, the sea cow was a major food source for Russian hunters seeking sea otter fur across the North Pacific. It lived only in the shallow waters off Bering and Copper Islands, in the Commander Islands some 100 miles east of Siberia in the Bering Sea. Slow-moving and unsuspicious, it grazed on seaweeds until its disappearance about 1768.

Georg Wilhelm Steller, the Bering expedition's naturalist and surgeon, was among the first to notice the sea cow. It resembled an overturned boat until it moved, when it revealed a huge, spindle-shaped body as much as twenty-five feet long, ending fore and aft with a disproportionately small, bristly muzzled head and a large, laterally lobed tail. We are indebted to Steller for the only scientific description of the sea cow—one of many species that bear his name.

The Steller's sea cow, along with the dugong and manatee, is a member of the order Sirenia. Although superficially resembling the modern whales and seals, the sirenians are actually descended from a pig-sized primitive ungulate, *Moeritherium*, which led a hippolike existence in the Upper Eocene some fifty million years ago. Oddly enough, its modern descendants, aside from the aquatically adapted sirenians, are the hyrax and the elephant.

Sirenians share a fusiform shape, a heavy-boned frame for stability, a horizontally flattened tail, a tough, wrinkled hide, bristly hairs around the lips, and a preference for coastal waters and estuaries where aquatic vegetation is abundant. They lack both an external ear and a dorsal fin. Two families —the manatee (Trichechidae) of the tropical Atlantic and Caribbean and the dugong (Dugongidae) of the Indian Ocean and East African and Indo-Malaysian waters—are the order's present representatives.

The sea cow, a dugongid, was the only recent family member to adapt

Adapted from *Marine Mammals of Eastern North Pacific and Arctic Waters*, ed. by Delphine Haley. Pacific Search Press; Seattle, Washington; 1978.

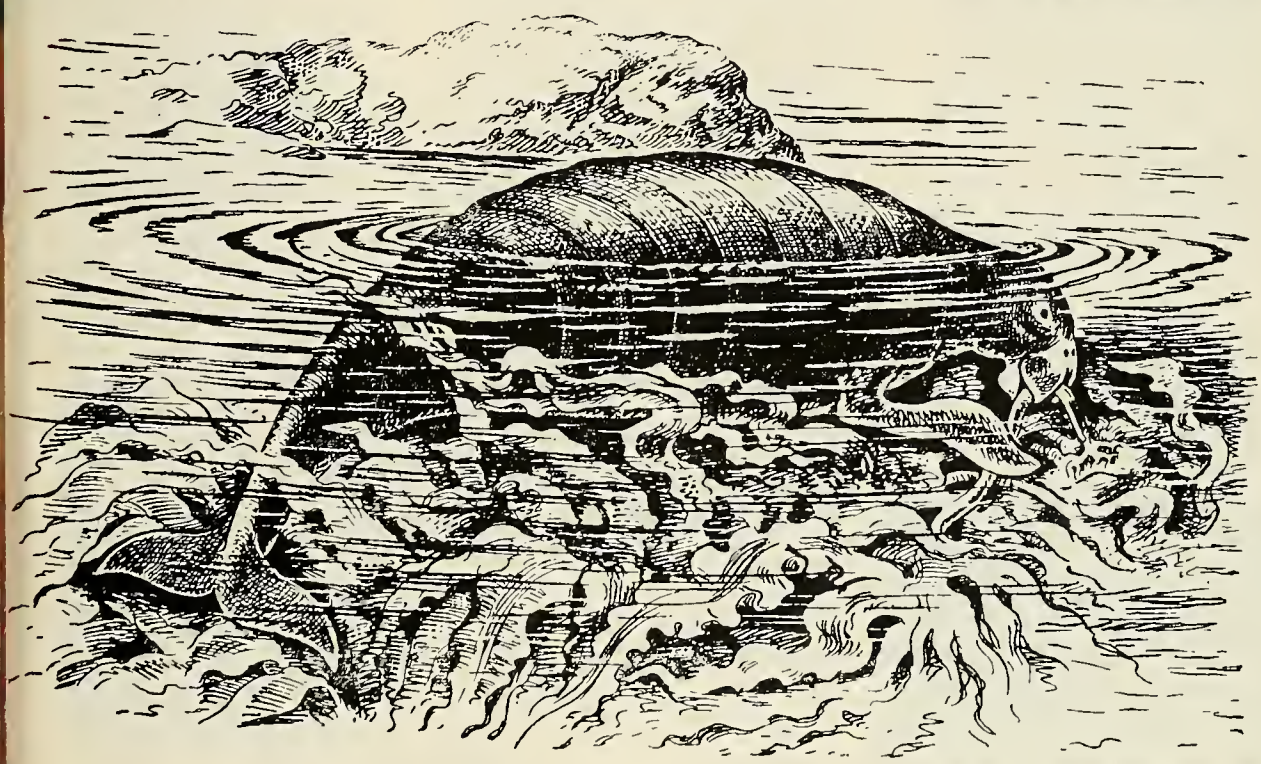


Illustration of a reputed Steller's sea cow

From the Soviet scientific journal *Priroda*, 1965



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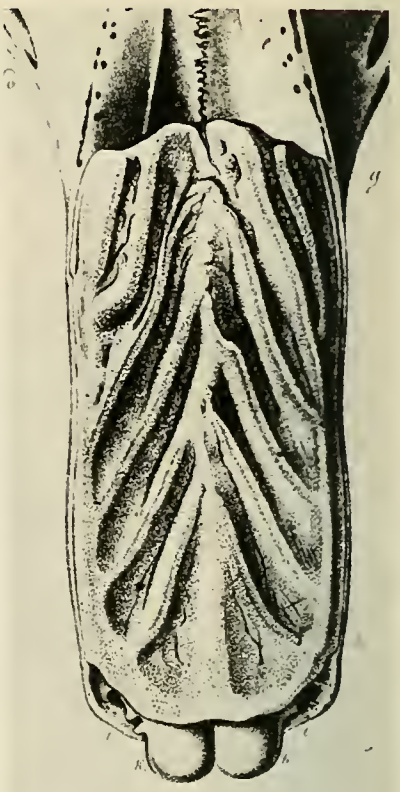
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to the cold waters of the north. To accomplish this, it evolved distinguishing traits, which Steller described. The sea cow was by far the largest sirenian, up to twenty-five feet in length. Its weight is confusing, for Steller records it at "200 pud," or 4.5 tons, and "1,200 pud," or 26.8 tons. (Marine mammalogist Victor Scheffer, using a clay model of the sea cow, has calculated its weight at 7 tons for a sea cow some twenty-five feet long.) Four inches of fat—nine in some places—provided insulation from the cold, and an inch-thick hide furnished protection from the abrasions of ice and surf-pounded rocky coasts. Its hairless, black, elephantlike hide—sometimes marked with white spots and zones—displayed a very rough cuticle, particularly around the head, eyes, ears, breasts, and under the forelimbs. The hide was uneven, full of grooves, wrinkles, and funnel-shaped lesions, or pits, gnawed out by a parasitic amphipod later named *Cyamus rhytina*. Seagulls were known to sit on the sea cows' backs and feed on these parasites.

Steller's descriptions of the sea cow and other North Pacific sea mammals were published posthumously in 1751 by the Saint Petersburg Academy of Science under the title *De Bestiis Marinis*. He related the creature to the one called manatee by the Spaniards in America and sea cow by the English and Dutch. In noting its ungulate characteristics, he wrote,

> These animals, like cattle, live in herds at sea, males and females going together and driving the young before them about the shore. They are occupied with nothing else but their food. The back and half the body are always seen out of the water. They eat in the same manner as the land animals, with a slow forward movement. They tear the seaweed from the rocks with the feet and chew it without cessation. . . . During the eating they move the head and neck like an ox, and after the lapse of a few minutes they lift the head out of the water and draw fresh air with a rasping and snorting sound after the manner of horses.

The sea cow had several unusual physical features. Instead of teeth, two flat plates—one attached to the upper jaw, another to the lower—served as chewing organs. (Subsequent examination of the plates identified them as horny, tubercle-filled structures.) Indented with wavy canals, the chewing plates fitted together for efficient mashing of seaweed. According to Steller, the sea cow's lips were "double and divided into internal and external lips," the protruding exterior upper lip being fourteen inches wide and fringed with thick bristles. In spite of its huge size, the animal's lidless eyes were no larger than those of a sheep. Nor was there any trace of an external ear; instead, within the wrinkles of the skin, there was an opening "hardly large enough for the insertion of a pea." The two-foot-long forelimbs were used for moving about in the shallows or for supporting the enormous body on slippery rocks. Most peculiar to Steller were the clawless forefeet, which he said resembled horses' hoofs, except that they were "furnished underneath with many short and closely set bristles like a scratch brush."



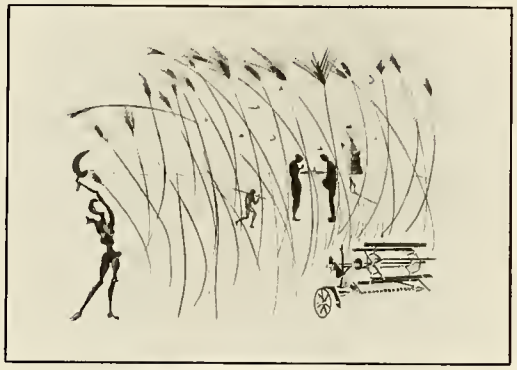
Rendering by J.F. Brandt of the chewing plates that took the place of teeth in the Steller's sea cow

From *Symbolae Sirenologicae*, 1849

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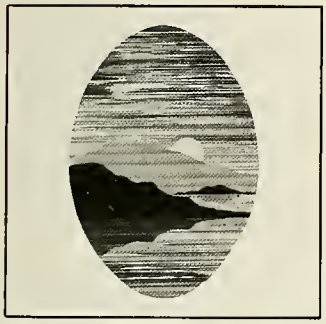
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A few weeks before leaving Bering Island in August 1742, Steller was able to dissect a sea cow that had been caught a few days previously. The specimen, a female, measured twenty-four feet in length and twenty feet at its greatest circumference. Its heart weighed 36½ pounds; the stomach stretched six by five feet and was so stuffed with seaweed that four strong men with a rope could scarcely move it. The length of the intestinal tract, from pharynx to anus, was 5,968 inches, or almost twenty times the animal's length. Steller took forty-seven measurements as he charted an anatomical map of the external and internal organs. In a brief description, he said the bones seemed surprisingly large and dense.

Steller noted the sea cows' behavior as he watched them during his nine-month stay on the island. He described their preference for shallow and sandy places along the shore, particularly at the mouths of freshwater streams where they sometimes came in so close that he stroked their backs. They pastured in family groups—a male, a female, and a "little tender one"; the adults always keeping the calf in front or, when traveling in a group, guarding it in the midst of the herd. Steller believed they were monogamous, with mating usually in early spring and most of the single newborns appearing in autumn after a presumed gestation of more than a year.

The sea cow's docile disposition and slow-moving habits, its (presumed) low reproduction rate and limited distribution were its undoing. In addition, its single-minded appetite for certain seaweeds made it heedless of all danger. One could safely row a boat into their midst while they grazed with heads underwater. Furthermore, even an injured sea cow would do little more than move out from the shallow water and return later, apparently bewildered. Aware of these habits, the Bering crew set out in the calm seas of May to capture and kill the delicious food source floating offshore. Their early attempts failed, but in June 1742 they hooked a sea cow from a boat and pulled it in by rope, a feat requiring the efforts of forty men on land. En route the beast struggled and moaned softly. On subsequent occasions, when one of the herd was hooked, its companions tried to rescue the captive by pressing on the rope or upsetting the boat with their backs. Once landed, the immense animal was carved into sections. The resultant steaks were described as "exceedingly savory"; even more delicious to the malnourished crew was the fat, which tasted like sweet almond oil.

Several weeks after the first sea cow was killed, the crew set out in a rebuilt boat for their Russian homeland. They took with them a supply of sea cow fat and salted meat, and news of a fortune to be made in sea otter, fox, and seal furs—with a food source in the sea cow. For the next twenty-seven years, successive fur-seeking expeditions slaughtered the sea cow. According to Steller's biographer, Leonhard Stejneger, the animal was rarely killed outright; instead, the wounded sea cow usually died slowly of its wounds. Only one out of five killed was actually con-

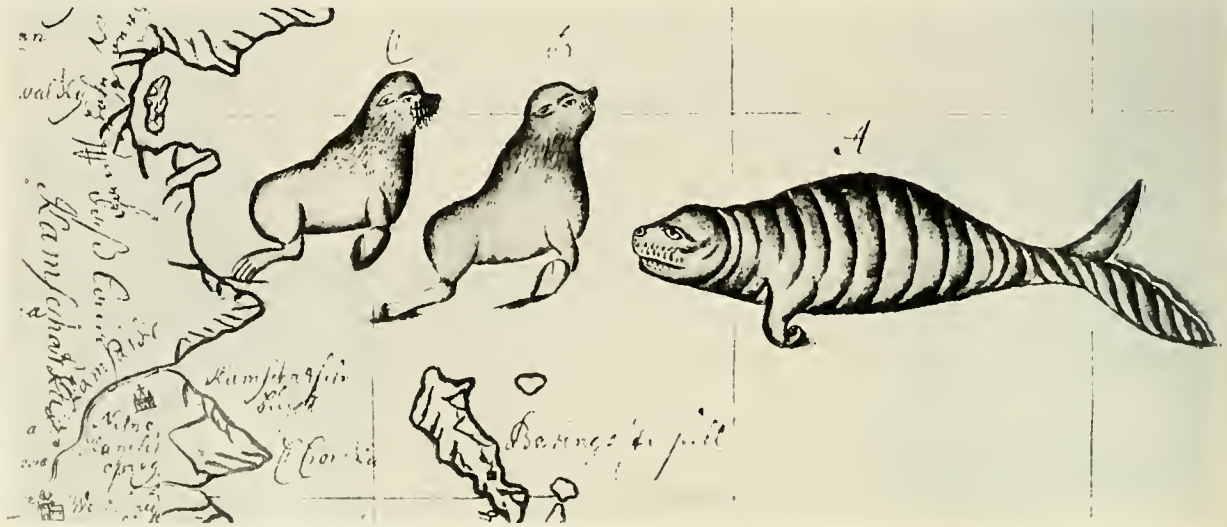


Chart section (attributed to Swen Waxell, an officer on Bering's 1741 expedition) depicting sea mammals of the Bering Sea: (a) sea cow, (b) sea lion, (c) fur seal



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sumed. In 1768 the last sea cow was killed, as recorded by explorer Martin Sauer.

Stejneger, after one and a half years on Bering Island, determined that if the fifteen river mouths where the sea cows congregated were visited by herds of only fifteen or twenty animals, they would have seemed abundant, even though the total population may not have been more than a few hundred. He estimated the population on Bering Island in Steller's time at fewer than 1,500 and concluded that those animals seen after 1768 were stray female narwhals. As for the cause of the rapid disappearance, he wrote in an article in *The American Naturalist*, 1887:

> There can hardly be any doubt that these animals were the last survivors of a once more numerous and more widely distributed species, which had been spared to that late date because man had not yet reached their last resort. It is, then, pretty safe to assume that this colony was not on the increase, and that, under the most favorable circumstances, the number of surviving young ones barely balanced the number of deaths caused by the dangers of the long winters. Under this supposition, every animal killed by a new agency—in this case by man—represents one less in the total number.

Sea cow "sightings" since 1768 have been the subject of much dispute, yet they persist—fueled perhaps by the wish that somehow Steller's beast has managed to survive. Expeditions in 1772 and 1783 failed to find any sea cows. This probably came as no surprise, for in 1755 a petition had been filed with authorities in Kamchatka by Peter Jakovleff, a mining engineer, requesting that sea cow hunting be restricted because the animals had already disappeared from Copper Island and would soon be gone from Bering Island. Some investigators extended the sea cow's demise beyond 1768. Among them was Norwegian explorer A.E. Nordenskiöld, who visited Bering Island for five days in 1879. While there, he spoke with three natives who stated that they had seen animals of this description as late as 1854.

Even in recent years, there have been reports of sea cows in the North Pacific. In July 1962, a Soviet research vessel near Cape Navarin, northeast of the Kamchatka Peninsula, came within 300 feet of six very large, unusual-looking dark-skinned animals feeding offshore. They had relatively small heads and bifurcated upper lips, which, perhaps because of their thick whiskers, seemed to project beyond their lower lips. The animals, twenty to twenty-seven feet long, maintained a tight formation, swam slowly, dived at regular intervals for short periods, and emerged high out of the water. A similar animal was seen in the same area on the following day. In an article in the Soviet scientific journal *Priroda*, the authors (A.A. Berzin, E.A. Tikhomirov, and V.I. Troinin) state that this sighting was only the most recent of several that had been reported in the region. To show that such reports were not impossible, they added that since the 1950s two completely new marine mammal species had been discovered—the ginkgo-toothed whale and the Gulf of California porpoise.

As anticipated by the authors, the sea cow sighting was challenged, also in *Priroda* (1965), by Soviet zoologist V.G. Heptner, who labeled it another in a trend of reporting Loch Ness-like creatures. He noted a gap of 194 years between the last trustworthy sea cow sighting (1768) and the Cape Navarin report (1962), and asked, could such a visible animal, one whose back was usually exposed and on which seagulls often



Drawing of a Steller's sea cow attributed to Plenisner, Bering's clerk on the 1741 voyage

From Pallas' *Zoographia Rosso—Asiatica*, vol. 1, plate 30. 1826



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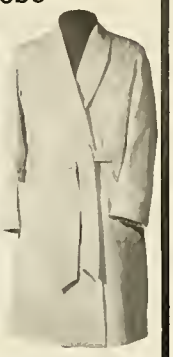
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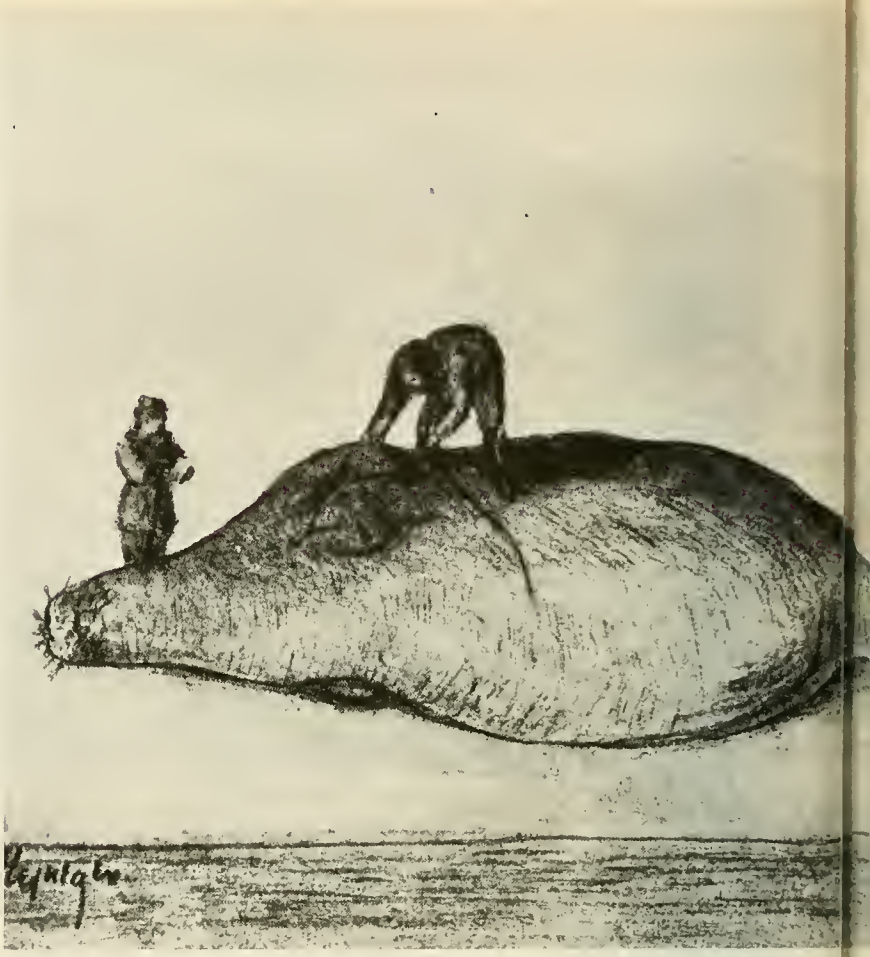
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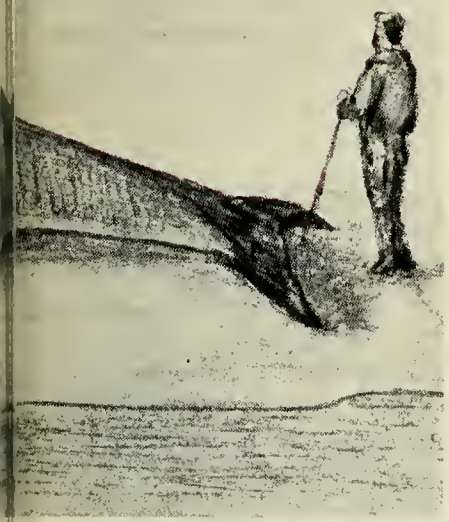


Leonhard Stejneger's reconstruction of a Steller's sea cow shows it being measured for the first time

perched, an animal that grazed near shore and left behind heaps of seaweed piled on the beach, have been overlooked all this time? Since the Soviet regime, he added, the faunal components of the region have been thoroughly known; and even earlier, when Russians and Americans hunted in the region, the sea cow was never mentioned.

In 1977 the sea cow surfaced again in an article in *Kamchatsky Komsomolets*, a newspaper in Petropavlovsk, Kamchatka. It described a sighting by fishermen in Anapkinskaya Bay, a region south of Cape Navarin. The author, Vladimir Malukovich of the Kamchatka Museum of Local Lore, interviewed one of the fishermen, who described an "unknown animal on a tidal belt" that was neither seal nor sea lion. The translation reads: "Its skin was dark, its extremities were flippers, its tail forked like a whale. A slight outline of round ribs was noticeable. We approached the animal, touched it and were surprised as its head bore an unusual form and its snout was long." When shown a drawing of a Steller sea cow, the fisherman stated that this was the animal—the same tail, fore flippers, and head—and he was surprised to learn that it presumably no longer existed.

Edward Mitchell, research biologist for the Canadian Department of Fisheries, has suggested that the unknown animal may have been a stray northern elephant seal. This large pinniped, whose usual range extends from Baja California to northern British Columbia, would fit the description: large in size, dark in color, and having a prominent snout. Its bipartite tail, if compressed, might have resembled a forked tail. The northern elephant seal has shown a tendency to wander thousands of miles from its normal centers of abundance. It has been seen at Prince of Wales Island, Alaska; at Midway Island in the mid-Pacific; and at Ugamak Island in the Aleutians, an area not far



From *Bering's Voyages*, by F.A. Golder. American Geographical Society, New York, 1922, 1925

from the sea cow's former grazing grounds in the Bering Sea.

Nonetheless, Mitchell believes that the extinct status of the Steller's sea cow is a presumption. He says: "There simply haven't been exhaustive inventories of marine vertebrates so that one could state unequivocably that this or any species does not survive." Rather than speculate further, he suggests that it would be a simple, albeit costly, effort to survey the area by ship. "While a lack of sightings may not resolve the issue," he says, "a confirmed sighting or a capture certainly would."

Aside from such reports, the sad fact remains that there is no hard proof that the Steller's sea cow survived, at least for very long, past 1768. Beyond this, the evidence is insubstantial—as elusive as the North Pacific mists. However unwittingly, it looks like humans struck the last blow and Steller's giant browser perished—the victim of human appetites. □



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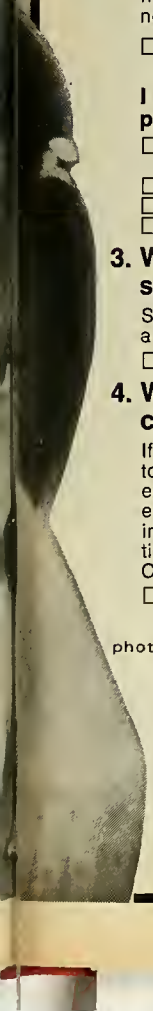


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by Stephen Jay Gould

The Panda's Peculiar Thumb

When nature uses a Tinkertoy approach, evolution's role becomes more apparent

Few heroes lower their sights in the prime of their lives; triumph leads inexorably on, often to destruction. Alexander wept because he had no new worlds to conquer; Napoleon, overextended, sealed his doom in the depth of a Russian winter. But Charles Darwin did not follow the *Origin of Species* (1859) with a general defense of natural selection or with its evident extension to human evolution (he waited until 1871 to publish *The Descent of Man*), but with his most obscure work, a book entitled: *On the Various Contrivances by Which British and Foreign Orchids Are Fertilized by Insects* (1862).

Darwin's many excursions into the minutiae of natural history—he wrote a taxonomy of barnacles, a book on climbing plants, and a treatise on the formation of vegetable mold by earthworms—won him an undeserved reputation as an old-fashioned, somewhat doddering describer of curious plants and animals who had one lucky insight at the right time. A rash of Darwinian scholarship has laid this myth firmly to rest during the past twenty years. Before then, one prominent scholar spoke for many ill-informed colleagues when he judged Darwin as a "poor joiner of ideas . . . a man who does not belong with the great thinkers."

In fact, each of Darwin's books played its part in the grand and coherent scheme of his life's work—demonstrating the fact of evolution and defending natural selection as its primary mechanism. Darwin did not study orchids solely for their own sake. Michael Ghiselin, a California biologist who finally took the trouble to read all of Darwin's books (see his *Triumph of the Darwinian Method*, University of California Press), has correctly identified the treatise on orchids as an important battle in Darwin's campaign for evolution.

Darwin began with an important evolutionary premise: continued self-fertilization is a poor strategy for long-term survival. With self-fertilization, offspring carry only the genes of their single parent, and populations do not maintain enough variation for evolutionary flexibility in the face of environmental change. Thus, plants bearing flowers with both male and female parts usually evolve a mechanism to ensure cross-pollination. Orchids have formed an alliance with insects. They have evolved an astonishing variety of "contrivances" to attract insects, guarantee that their sticky pollen adheres to the visitor, and ensure that the attached pollen comes in contact with female parts of the next orchid the insect visits.

Darwin's book is a compendium of these contrivances, the botanical equivalent of a bestiary. And like the medieval bestiaries, it is designed to instruct. The message is paradoxical but profound. Orchids manufacture their intricate devices from the common components of flowers, parts usually fitted for very different functions. If God had designed a beautiful machine to reflect his wisdom and power, surely he would not have used a collection of parts generally fashioned for other purposes. Orchids were not made by an ideal engineer; they are jury-rigged from a limited set of available components. Thus, they must have evolved from ordinary flowers.

Thus, the paradox: Our textbooks like to illustrate evolution with examples of optimal design—nearly perfect mimicry of a dead leaf by a butterfly or of a poisonous species by a palatable relative. But ideal design is a lousy argument for evolution, for it mimics the postulated action of an omnipotent creator. Odd arrangements and funny solutions are the proof of evolution—paths that a sensible God would never tread but that a natural process, constrained by history, follows perforce. No one understood this better than Darwin. Ernst Mayr has shown how Darwin consistently turned to organic parts and geographic distributions that make the least sense for his defense of evolution. Which brings me to the giant panda and its "thumb."

Giant pandas are peculiar bears, members of the order Carnivora. Conventional bears are the most omnivorous representatives of their order, but pandas have restricted this catholicity of taste in the other direction—they belie their order by subsisting entirely on bamboo. They live in dense bamboo forests at high elevations in the mountains of western China. There they sit, largely unthreatened by predators, munching bamboo ten to twelve hours each day.

As a childhood fan of Andy Panda, and a former owner of a stuffed toy won by some fluke when

Continued on page 24

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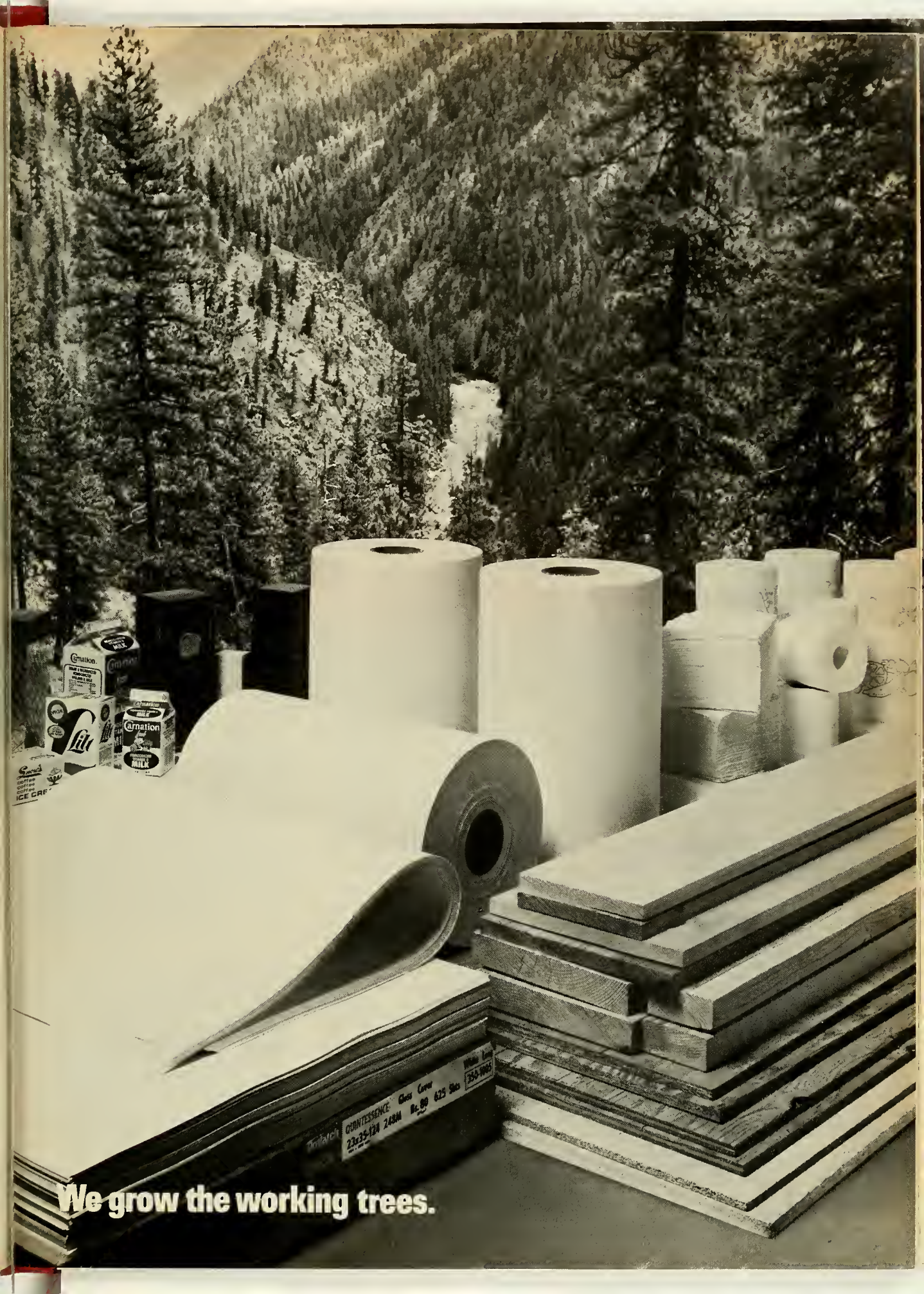
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D. L. Cramar

all the milk bottles actually tumbled at the county fair, I was delighted when the first fruits of our thaw with China went beyond Ping-Pong to the shipment of two pandas to the Washington zoo. I went and watched in appropriate awe. They yawned, stretched, and ambled a bit, but they spent nearly all their time feeding on their beloved bamboo. They sat upright and manipulated the stalks with their forepaws, shedding the leaves and consuming only the shoots.

I was amazed by their dexterity and wondered how the scion of a stock adapted for running could use its hands so adroitly. They held the stalks of bamboo in their paws and stripped off the leaves by passing the stalks between an apparently flexible thumb and the remaining fingers. This puzzled me. I had always learned that a dexterous, opposable thumb stood among the hallmarks of human success. We had maintained, even exaggerated, this important flexibility of our primate forebears, while most mammals had sacrificed it in specializing their digits. Carnivores run, stab, and scratch. My cat manipulates me in the psychological sense, but he'll never type or play the piano.

So I counted the panda's other digits and received an even greater surprise: there were five, not four. Was the "thumb" a separately evolved sixth finger? Fortunately, the giant panda has its bible, a monograph by D. Dwight Davis, late curator of vertebrate anatomy at Chicago's Field Museum of Natural History. Probably the greatest work of modern evolutionary comparative anatomy, it contains more than anyone would ever want to know about pandas (*The Giant Panda, a Morphological Study of Evolutionary Mechanisms*). Davis had the answer, of course.

The panda's thumb is not, anatomically, a finger at all. It is made from a bone called the radial sesamoid, normally a very small component of the wrist. In pandas, the radial sesamoid is greatly enlarged and elongated until it almost equals the true digits in size. The radial sesamoid underlies a pad on the panda's forepaw; the five digits form the framework of another pad, the palmar. A shallow furrow separates the two pads and serves as a channelway for bamboo stalks.

The panda's thumb comes

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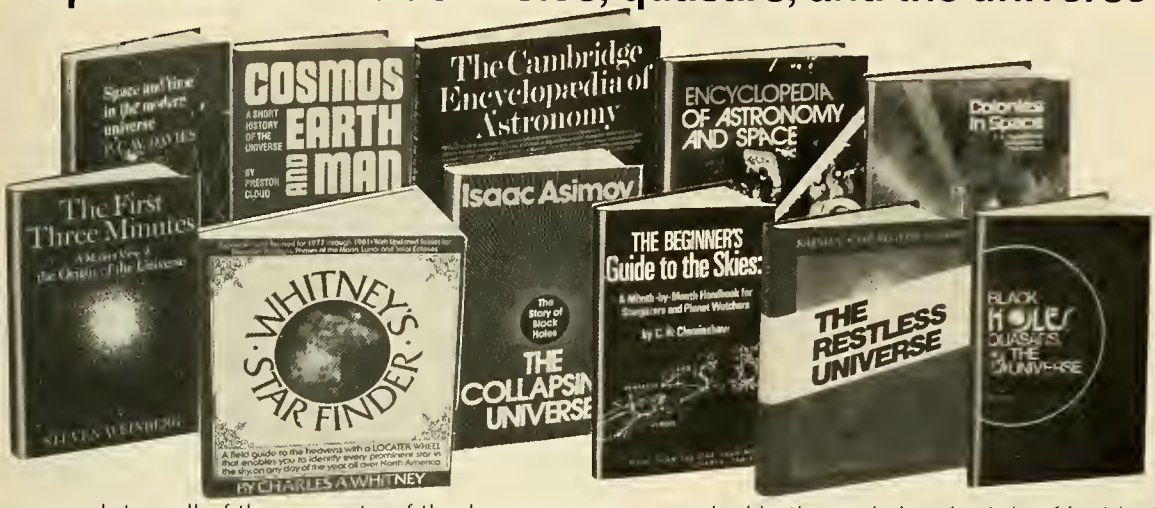
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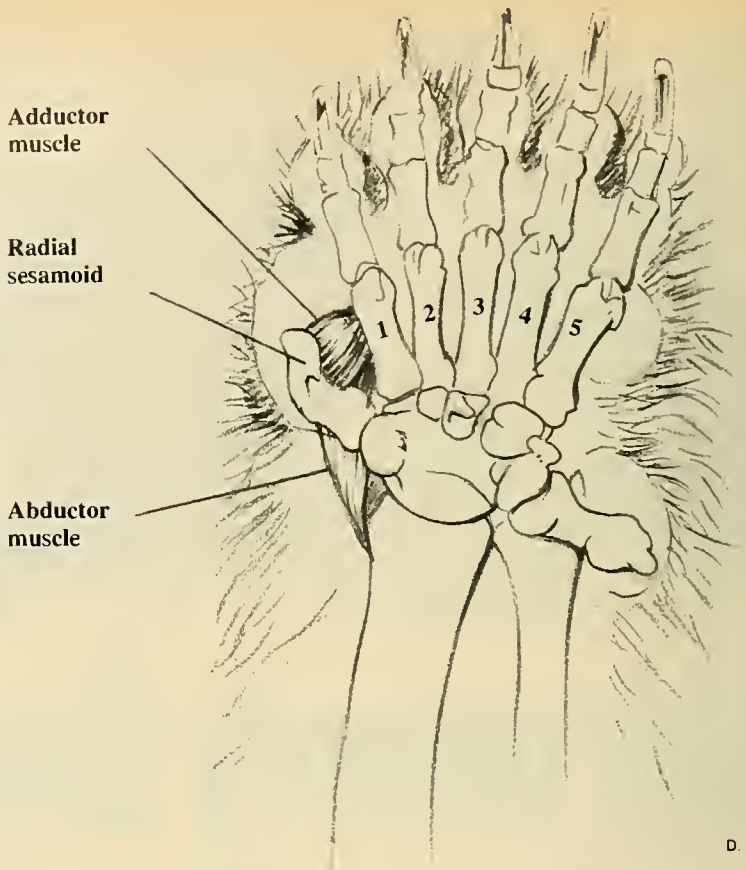


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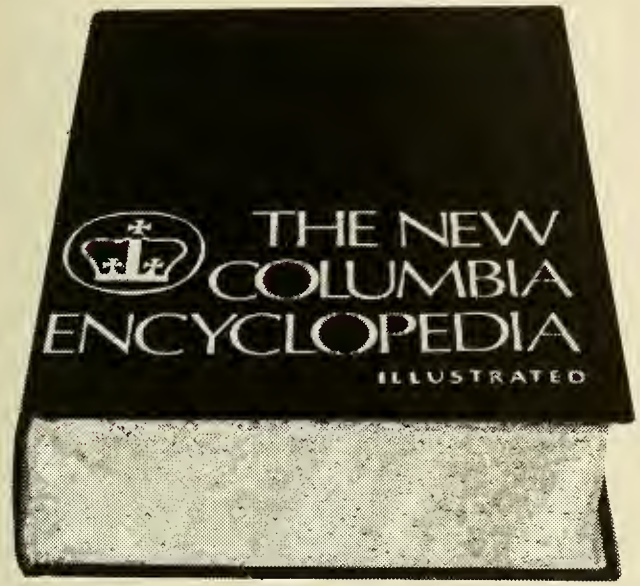
equipped not only with a bone to give it strength but also with muscles to sustain its agility. As with the radial sesamoid, these muscles did not arise *de novo;* like the parts of Darwin's orchids, they are familiar bits of anatomy remodeled for a new function. The abductor of the radial sesamoid (the muscle that pulls it away from the true digits) bears the formidable name *abductor pollicis longus* ("the long abductor of the thumb"—*pollicis* is the genitive of *pollex*, Latin for "thumb"). Its name is a giveaway. In other carnivores, this muscle attaches to the first digit, or true thumb.

Does the anatomy of other carnivores give us any clue to the origin of this odd arrangement in pandas? Davis points out that ordinary bears and raccoons, the closest relatives of giant pandas, far surpass all other carnivores in using their forelegs for manipulating objects in feeding. Pardon the backward metaphor, but pandas, thanks to their ancestry, began with a leg up for evolving greater dexterity in feeding. Moreover, ordinary bears already have a slightly enlarged radial sesamoid.

In most carnivores, the same muscles that move the radial sesamoid in pandas attach exclusively to the base of the pollex, or true thumb. But in ordinary bears, the long abductor muscle ends in two tendons: one inserts into the base of the thumb as in most carnivores, but the other attaches to the radial sesamoid. Two shorter muscles also attach, in part, to the radial sesamoid in bears. "Thus," Davis concludes, "the musculature for operating this remarkable new mechanism—functionally a new digit—required no intrinsic change from conditions already present in the panda's closest relatives, the bears. Furthermore, it appears that the whole sequence of events in the musculature follows automatically from simple hypertrophy of the sesamoid bone."

The radial thumb of pandas is a complex structure formed by marked enlargement of a bone and an extensive rearrangement of musculature. Yet Davis argues that the entire apparatus arose as a mechanical response to growth of the radial sesamoid itself. Muscles shifted because the enlarged bone blocked them short of their original sites. Moreover, Davis postulates

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Marsh *Epipactis*, lower sepals removed



Runway of labellum depressed after insect lands



Runway of labellum raised after insect crawls into cup below

D. L. Cramer

that the bigger radial sesamoid may have been fashioned by a very simple genetic change, perhaps a single mutation affecting the timing and rate of growth.

In a panda's foot, the counterpart of the radial sesamoid, called the tibial sesamoid, is also enlarged, although not so much as the radial sesamoid. Yet the tibial sesamoid supports no new digit, and its increased size confers no advantage, so far as we know. Davis argues that the coordinated increase of both bones, in response to natural selection upon one alone, probably reflects a simple kind of genetic change. Repeated parts of the body are not fashioned by the action of individual genes—there is no gene "for" your thumb, another for your big toe, or a third for your pinky. Repeated parts are coordinated in development; selection for a change in one element causes a corresponding modification in others. It may be genetically more complex to enlarge a thumb and *not* to modify a big toe, than to increase both together. (In the first case, a general coordination must be broken, the thumb favored separately, and correlated increase of related structures suppressed. In the second, a single gene may increase the growth rate in a field regulating the development of digits.)

The panda's thumb provides an elegant zoological counterpart to Darwin's orchids. An engineer's best solution is debarred by history. The panda's true thumb is committed to another role, too specialized for a different function to become an opposable, manipulating digit. So the panda must use parts on hand and settle for an enlarged wrist bone and a somewhat clumsy, but quite workable, solution. The radial thumb is, to use Michael Ghiselin's phrase, a contraption, not a lovely contrivance. But it does its job and excites our imagination all the more because it builds on such improbable foundations.

Darwin's orchid book is filled with similar illustrations. The marsh *Epipactis*, for example, uses its labellum—an enlarged petal—as a trap. The labellum is divided into two parts. One, near the flower's base, forms a large cup filled with nectar—the object of an insect's visit. The other, near the flower's edge, forms a sort of landing stage. An insect alighting on this runway depresses it and thus gains entrance to the nectar cup beyond. It enters the cup, but the runway is so elastic that it instantly springs up, trapping the insect within the nectar cup. The insect must then back out through the only available exit—a path that forces it to brush against the pollen masses. A remarkable machine but all developed from a conventional petal, a part readily available in an orchid's ancestor.

Darwin then shows how the same labellum in other orchids evolves into a series of ingenious devices to ensure cross-fertilization. It may develop a complex fold that forces an insect to detour its proboscis around and past the pollen masses in order to reach nectar. It may contain deep channels or guiding ridges that lead insects to both nectar and pollen. The channels sometimes form a tunnel, producing a tubular flower. All these from a part that began as a conventional petal in some ancestral form. Yet nature can do so much with so little that it displays, in Darwin's words, "a prodigality of resources for gaining the very same end, namely, the fertilization of one flower by pollen from another plant."

Darwin's metaphor for organic form reflects his sense of wonder that evolution could fashion such a world of diversity and adequate design with such limited raw material:

> Although an organ may not have been originally formed for some special purpose, if it now serves for this end we are justified in saying that it is specially contrived for it. On the same principle, if a man were to make a machine for some special purpose, but were to use old wheels, springs, and pulleys, only slightly altered, the whole machine, with all its parts, might be said to be specially contrived for that purpose. Thus throughout nature almost every part of each living being has probably served, in a slightly modified condition, for diverse purposes, and has acted in the living machinery of many ancient and distinct specific forms.

We may not be flattered by the metaphor of refurbished wheels and pulleys, but consider how well we work. Nature is, in biologist François Jacob's words, an excellent tinkerer, not a divine artificer. And who shall sit in judgment between these exemplary skills?

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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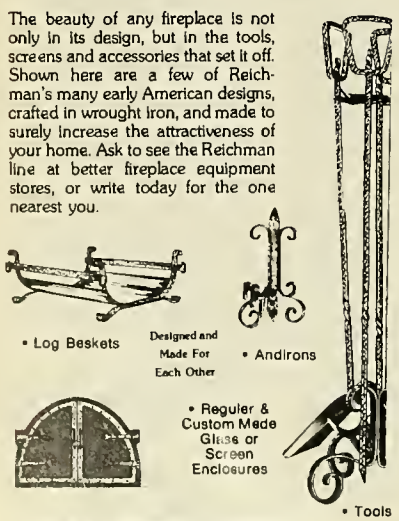
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A Matter of Taste — by Raymond Sokolov

Root Awakening

Although unfamiliar outside the tropics, manioc provides subsistence to millions

"Once upon a time men had neither sweet manioc nor fire. An old woman was given the secret of the first by the ants; and her friend, the nocturnal swallow . . . would obtain fire for her (keeping it hidden in his beak), so that she could cook the manioc, instead of heating it by exposure to the sun or by putting it under her armpits.

"The Indians found the old woman's manioc cakes excellent and asked how she prepared them. She replied that she simply baked them in the heat of the sun. The swallow, amused by this falsehood, burst out laughing, and the Indians saw flames coming from his mouth. They forced it open and took possession of the fire. Since then nocturnal swallows have had gaping beaks."

Tacuna myth.
Quoted by Claude Lévi-Strauss
in *The Raw and the Cooked.*

Manioc—the staff of life for some 200 million people in the tropics—is probably the most mysterious and misunderstood of all important foods. In one form or another, this prolific, easily cultivated plant supplies the bulk of food energy for the masses of Brazil and black Africa. Whole cuisines are built on *Manihot utilissima* (alias *M. esculenta*); as fufu or gari or farofa, it is the tropical world's cornflakes and potato chips and bread all rolled into one indispensable, all-purpose, universal starch. But I will bet that almost no readers of this magazine think they have eaten or even seen it.

Actually, manioc, in the processed form of tapioca, does occasionally appear on American tables. And anyone who pays attention to tropical produce sold to Hispanic customers in New York and other North American cities with Caribbean enclaves will have noticed those bulky, tuberous, whitish vegetables that are called yuca in Spanish and cassava in English. This chaos of nomenclature undoubtedly adds to the confusion surrounding a remarkable plant.

By the time the Portuguese discovered manioc among the indigenous Tupinambá peoples of the Brazilian coast, this shrubby perennial of the spurge, or Euphorbiaceae, family had been under cultivation in this hemisphere for millenniums. Manioc roots are depicted on 4,000-year-old Peruvian pottery. It is called yuca in Aztec and Maya chronicles and was probably domesticated in Mesoamerica. The other vernacular names for *M. utilissima* are all pre-Columbian, from Arawak, Carib, or other tribal languages in tropical America. Tapioca seems to have always applied to the cooked starch; yuca may have referred only to the edible product; and mainuca (the Carib form of manioc) to the whole root. At any rate, modern usage reflects the accidents of colonial occupation. Anglophone Africa says cassava; Spanish speakers settled on yuca; the French say manioc; Asians call all forms of manioc tapioca. Everyone agrees, however, that *Manihot* is an extremely poor source of nutrition. It is roughly one percent protein, half as rich as potatoes. The rest is almost entirely starch, but that is the point.

Like the potato in the diet of the Irish in the nineteenth century, manioc makes life for millions pos-

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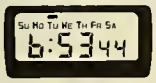
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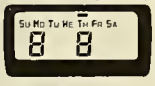
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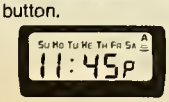


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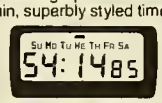
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sible because it provides cheap, abundant food energy. Protein, vitamins, and other vital nutriments must come from other sources. This is why most meals in tropical Africa consist of lumps of cassava paste or porridge dipped in protein-rich sauce. If such meals are only a subsistence diet, they do at least provide subsistence. And there is also good evidence that people brought up on manioc love it and regard its innumerable cooked forms with all the fussiness and appetite that we reserve for lobster or for very thin, pounded white veal.

Nontropical peoples like us don't know much about manioc because it doesn't grow in our climate. But in the zone bounded roughly by the 30th parallels, north and south, it flourishes in the poor soil of rain forests. It resists locusts and other pests. It requires only the most cursory care and the simplest agricultural skills. Since it grows fast and is a plant for all seasons, it is ideally adapted to the seminomadic, slash-and-burn horticulture of aboriginal Amazonia and West Africa. Manioc cuttings mature in only a few months to plants averaging nine feet in height. Their roots swell into tuberous enlargements one to two feet long and two to six inches across. These weigh up to ten pounds, and a single plant can produce fifty pounds of edible root in stump-studded, crudely cultivated dooryard plots. But there is a catch.

Manioc is often toxic. Some plants generate lethal doses of prussic (hydrocyanic) acid. No doubt this faculty protects the plant from animal and insect attacks. The poison is not present in undisturbed plants. Small sacs under the peel or bark exude a milky latex when the bark is cut. This white juice contains a cyanogenetic glucoside (manihotoxine), which breaks down into prussic acid, glucose, and acetone. The natural enzyme linase frees the acid, and its action can be promoted by soaking the root in water, by cutting up the root to increase contact between linase and the acid, or by heating (but not above 75°C [167°F], since higher temperatures kill the linase). Once the acid has been liberated into the air by one or several of these methods, the manioc is safe to eat.

Preliterate manioc consumers discovered how to handle poisonous manioc. They also noticed that some plants were not toxic and so they assumed, as did botanists until recently, that there were two basic varieties of manioc, "sweet" and poisonous. More careful study has shown that the observed difference is not genetic; it comes from the environment. Researchers have found that clones from poisonous plants will grow up sweet in new settings and vice versa. Indeed, the nature of manioc is so adaptable that varietal names have only limited value, for clones vary significantly under diverse conditions. Perhaps, then, we should not smile too broadly at the fanciful vernacular names for manioc used by the Yoruba of West Africa. The high-yielding *onigbese duro gbowo* ("Creditor, wait to be paid") and the quick-cooking *alejo duro ndana* ("Stranger, wait, and I cook") are probably more practical designations, because they describe specific results, than more technical descriptions that imply something about future generations of plants from the same parent.

Despite such diversity, manioc roots of all kinds are processed in the same basic ways once they have been detoxified. They are pounded, pressed, strained, ground, and dried to form meal, flour, starch, and stock. Meal is the principal product. In Brazil a wooden bowl of raw *farinha de mandioca* is served at every meal as a condiment for rice or beans, and it is still made by a process not far removed from the original Indian technology. The primordial method involved grating the peeled root with a flat, stone-studded piece of wood and then pressing it in a tipiti, a cylindrical basket whose diameter and volume shrink when the ends are pulled. The pressed manioc is sieved and then toasted over a fire in a shallow pan.

True manioc flour is made from dried root that is pulverized. To obtain starch, both Indians and non-Indians put grated, pressed manioc in water, stir, and let the starch settle. If the starch is sifted while damp and then toasted, it clumps into tapioca balls. Raw starch is used in laundries and for sizing new clothes.

The toxic, milky liquid, a by-product of all these processes (variously known as cassareep and manipuera), can be made safe by heating and used as a sauce base.



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Finally, like all other starchy substances, manioc can be fermented. Amazonian women and children chew the manioc to impregnate it with saliva and hasten the fermentation along. Although manioc beer probably has no future as a beverage in industrial societies, whole roots and manioc meal are worth trying as alternatives to more familiar starches. Toasted meal, called farofa in Brazil and gari in West Africa, is a real treat locally available at Hispanic and Brazilian specialty shops. Perhaps the best way to try it is in a gritslike recipe, imoyo eba, brought to Nigeria by ex-slaves returning to their homeland from Brazil, following the same route as manioc itself.

First, the manioc meal should be toasted in a pan lightly greased with oil. Stir constantly. Then sprinkle this gari into a simmering pot containing 1½ cups of chicken stock and 4 tablespoons of tomato paste. Cook briefly, until firm. Toasted meal can also be stirred into scrambled eggs or mixed with chopped hard-boiled eggs, onion, and garlic to make a stuffing for poultry. You might try heating pork gravy, beaten egg, and gari to produce a sort of tropical Yorkshire pudding.

If all else fails, you can fall back on tapioca. Most American markets supply only instant tapioca, finely ground pellets also called grists. The old-fashioned pearl tapioca makes a nice change. These larger granules (or the smaller ones) can be thickened with wine or fruit juice or, in a particularly lush variation, with coconut milk (see recipe).

Pearl tapioca must be soaked in double its volume of water for at least an hour or until the water is absorbed. Nothing, of course, prevents you from buying a whole root from a tropical fruit and vegetable grocer, chopping it, soaking it, grating it yourself in a processor, and making your own cassava flat bread. But if you are going to embark on so strenuous an act of symbolic solidarity with the Third World (where more practical, but similarly inclined, First World botanists are now trying to develop high-protein strains of manioc) you should at least be careful you do not mistakenly buy a casaba—a melon named after a place in Turkey—or a yucca—a member of the lily family whose bloom is the state flower of New Mexico.

Nigerian Coconut Milk Tapioca
(Adapted from *A West African Cookbook*, by Ellen Gibson Wilson)

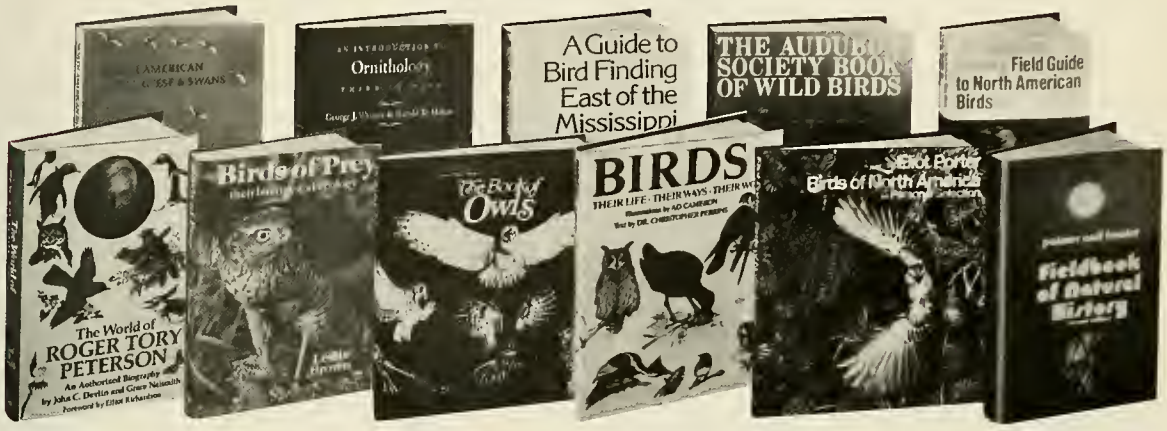
1 fresh coconut
3 tablespoons minute tapioca
2 tablespoons sugar
¼ teaspoon nutmeg or allspice
⅛ teaspoon salt

1. To make coconut milk:
   A. Preheat oven to 325°.
   B. Punch holes in the coconut eyes and drain off the liquid into a bowl. Reserve liquid.
   C. Heat coconut in oven for 25 minutes. This may crack the shell enough to break the nut apart, but if more help is needed, tap the shell with a hammer. (Throwing the coconut onto a cement floor also does the trick.) Remove the husk and pare the brown coating from the meat.
   D. Grate the coconut meat finely or cut it into small pieces and shred in a blender or processor. Collect in a bowl.
   E. Pour 1 cup boiling water over the grated coconut. Let stand 20 minutes. Strain through a cloth or fine sieve, squeezing or pressing to extract all the liquid and flavor. Add this liquid to the reserved natural milk.
   F. Return grated meat to the bowl and pour another cup of boiling water over it. Let stand another 20 minutes and squeeze or press in a cloth or sieve as before. Add resultant liquid to the other, reserved liquid. Discard grated meat. (You can substitute cups of prepared grated coconut, but the yield will be somewhat smaller. One frest coconut should yield about 2 cups of milk.)
2. Mix coconut milk with all other ingredients and let soak for about 5 minutes.
3. Set over moderate heat for 6 to 8 minutes, stirring constantly.
4. Pour into a bowl or serving dishes.
5. Eat hot with cow's milk for breakfast or chill for dessert.

Yield: 2 to 3 servings

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Trekking in the Amazon Forest

Text and photographs by Dennis Werner

Laden with possessions and produce, Brazil's Mekranoti Indians spend much of the year traveling en masse through the jungle

Full of thorny palms, stinging ants, scorpions, and poisonous caterpillars, the Amazon forest of the southern part of the Brazilian state of Pará seems less than inviting to most travelers. Yet the Northern Kayapó Indians who inhabit this region spend a considerable amount of time wandering about in the forest. Not only is the forest cool, since the sun rarely penetrates the thick canopy of broad leaves and hanging lianas, but materials for baskets and ropes are never more than twenty feet away, and food, mostly animal, is also available.

Local game consists mainly of small animals—macaws, armadillos, pacas (a species of large rodent), and monkeys. On very rare occasions hunters come across a herd of peccaries or a fat tapir. Although not as plentiful as the Indians would like, the local fauna has so far been adequate. For the Indians, the Amazon is neither a hell nor a paradise.

In the forests to the west of the Iriri River lies a community of about three hundred Northern Kayapó Indians, called the Mekranoti. Their village is built in a circle of square, thatched houses—one-room for the most part—surrounding a clearing of hard clay. In the middle of this plaza is the men's house, which serves as a meeting place, a factory for manufacturing weapons or ceremonial gear, a social club, and a transient hotel for bachelors or married men whose wives have just given birth.

At least two or three times a year, at irregular intervals, the Mekranoti pack up their possessions, their pet birds and dogs, and their children, and leave their village en masse. Heavily weighed down with pots, guns, infants, and baskets of food, they spend the next three weeks to three months wandering about the tropical forest. Almost every day the entire group abandons its day-old camp and moves to a new location, often only a half-hour's walk away.

This behavior is not unusual among hunters and gatherers, societies that bring collected foods into camp every day and thus avoid storing or carrying large quantities of comestibles. The Mekranoti, however, are not hunters and gatherers but swidden agriculturists. When they depart on trek, they carry huge bundles of cultivated manioc root and manioc flour, sweet potatoes, and bananas, often making return trips to village and forest gardens to replenish dwindling supplies. While on trek, the Mekranoti gather and eat a great variety of wild fruits and tubers, but they probably have never managed to survive on wild foods alone.

Today, even though the Indians can wander in a huge tract of forest, abounding in diverse and often unclassified flora, they consume only a few wild products in any quantity—Brazil nuts available year-round, tubers found in mountainous areas in the dry summer months from June through August, and *açaí*, a rainy season palm berry. But these products cannot provide the essential calories that only garden staples can supply. Yet despite this lack of wild vegetable foods, the Mekranoti often go on long trips lasting several months, requiring them to haul heavy loads of garden produce.

While greater contact with contemporary Brazil may eventually destroy Mekranoti trekking patterns, the practice is still quite strong. Although even the oldest Indian cannot remember a day when he did without Western goods, the village's first peaceful contact with modern civilization occurred only in 1954. Previously, the Mekranoti raided other Indian and Brazilian settlements for guns, pots, and chickens. Fighting continued for years after 1954, and as recently as 1967, the Mekranoti were still raiding their traditional enemies, the Kreen Akrore.

Since 1966, the almost continuous presence of missionaries or government personnel in the Mekranoti village seems to have dampened the group's bellicosity. Nevertheless, they are still a long way from integration into contemporary Brazilian society. Only one Indian speaks any Portuguese, none can handle money well, and most have a great deal of difficulty counting above six. The group's traditional social structure, ceremonies, and means of subsistence, including trekking, are still very much alive.

The Mekranoti have not yet clashed with Brazil's development of the Amazon Basin and continue to enjoy unhindered and exclusive access to the vast area of tropical

Most treks are part of ceremonies that end in elaborate festivities when the Mekranoti return to their village. At right, a child is dressed for the celebration in feathers that he has inherited the right to wear.





forest that they have been calling home for the past twenty years. They have limited their recent trekking activities to the confines of this region although there is no apparent pressure to do so.

Before 1954, their raiding activities took them much farther afield than they now need to go. In 1947, one party traveled as far east as the Araguaia River to attack the Tapirapé Indians, while another section wandered westward to the Tapajós River—a distance of almost 500 miles. During these lengthy trips the Indians subsisted on garden produce stolen from other Indian or Brazilian settlements.

But today, FUNAI (the Brazilian Indian Foundation) gives them Western products in exchange for artifacts and Brazil nuts collected by the younger men on special expeditions. Since the Mekranoti no longer need to rob their neighbors, they have settled down to some extent, breaking the monotony of daily routine with what they probably consider trips around the corner.

The Mekranoti go off on trek during both the wet season and the short dry season. During the year I recently spent with these Indians there was not a drop of rain from June 17 until August 17. The small tributary that supplied the village with drinking and bathing water dried up into a stagnant pool. When the rains do come, they are torrential, flooding large areas of the land around the village for much of the year.

Gardens must be burned and planted just before the rainy season begins about September. A few crops, notably corn, ripen early, but are quickly exhausted. The period of greatest productivity begins with the following dry season, when the Kayapó staples—manioc, bananas, and sweet potatoes—begin to dominate the gardens' three- or four-year life span.

Although the Mekranoti can choose from a greater variety of foods during the wet season, they



feel that they eat better during the dry season when their most-prized food—sweet potato—matures. Also, because the small game in the region is both easier to find and easier to approach during this season, hunters are significantly more likely at this time to return from a hunt with meat to feed their families. The easiest method of hunting—using modern flashlights to find game at night—works only during the dry season. Finally, abundant fishing catches are possible only when the streams are low and Indians can poison fish by beating timbó vines in the water. For all these reasons the Indians call the dry season *amêx kam,* literally, the "good time," as opposed to *na kam,* the "rainy time."

On treks during the wet season, the Mekranoti's daily movements between campsites are shorter. The Indians have more trouble making paths and walking through flooded land and must construct lean-tos as protection from the rain. In the dry season the distances between encampments are greater, but walking is easier, and the Indians are content to spend the night without shelter, sleeping on leaves scattered on the ground.

The Kayapó also organize different kinds of treks for different purposes, distinguishing above all between ceremonial and noncere-





Above left: On the last day of a trek, the women, who have returned to the village before the men, bathe for the final celebrations. Above: A woman plants sweet potatoes, the prized Mekranoti staple, in a village garden. Left: An aerial view of the Mekranoti village shows the men's house in the center, two circles of houses, and paths leading to gardens and the river.





Villagers return from a three-month trek in search of palm nuts for hair oil.

monial expeditions. Most Kayapó festivals involve a series of events lasting several months and are sponsored by parents who want to bestow special names on their children aged five to twelve. After the sponsoring relatives and the village chief decide on a ceremony, and the requisite masks—if any—are made, relatively low-keyed activities go on for a month or two. Village members take part in masked dances, early morning and evening sings, and occasional ritual processions—the three signs that a ceremony is in progress. A festival's close, however, calls for a day-long spectacle.

To feed all participants, the Mekranoti require a large supply of tortoises, for which they must go out on trek. And so, for about a month before the end of a Kayapó ceremony, the village empties out while everyone goes to the forest to gather and rack up as many tortoises as possible.

A typical day during a ceremonial trek starts about four in the morning when the men go to the camp men's house to begin their singing. Kayapó songs consist of heavily accented, regular rhythms, usually accompanied by rocking motions and ending with the Kayapó cadence, a sighing, semivoiced, downward slide. The men sing in deep voices with occasional falsetto barks scattered haphazardly throughout the melodic line.

As the first patches of dawn appear through the forest canopy, the morning sing comes to a close. Usually the men calculate the start of sings fairly accurately by observing the night sky, but when the moon is too new, singing may begin as early as one-thirty or as late as five-thirty. A sing ends with a series of yelps and exhortations addressed to men who have failed to appear that morning, such as, "Wake up! Do you want the Kreen Akrore to attack you in your sleep?" The men return to their respective families for a morning meal of cold sweet potatoes or other leftovers from the previous evening. Packing begins shortly thereafter and most people have abandoned their temporary homes by seven or seven-thirty.

Occasionally there is some con-





Above: In camp, a woman prepares a meat pie from grated manioc and game. Right: When camping during the dry season, families sleep on leaves in the open air.

fused argument over the site of a new camp, but construction usually begins with little delay. A camp consists of two or more long leantos that face each other. The men often help put up the basic frame, but construction generally falls to the women, who spend the next three or four hours gathering wild banana and palm leaves to finish the shelters.

By noon most of the structures are up and some women have already left their children with relatives while they chop wood for the large communal oven or for the small household fires that keep people warm at night. A few women gather *açaí* berries or wild bananas. Many busily make repeated trips to the previous day's encampment to fetch the garden supplies to feed the traveling village. Still other women lounge idly on their sleeping mats or calmly paint one of their children in delicate striped-line designs, the body decoration for which the Kayapó are famous. This routine continues for the afternoon, broken occasionally by a chilling Mekranoti wail, provoked by events ranging from an old woman's remembrances of things past to a fatal machete accident. Often such a wail welcomes back a young man who, having lost his way in the forest the previous day, has just returned to camp.

While the women build the houses, most of the men take off individually for the forest and a long day of hunting. A few younger men clear paths on which the families must travel, and some elders help transport garden produce or butcher game as the hunters return one by one. A successful hunter may return early, give his catch to the ceremonial sponsor, and relax for the rest of the day. Unlucky hunters are apt to return just before dusk.

After a bite to eat at home, the men like to congregate for an evening's gossip or singing in the men's house. While the ceremonial sponsor provides food for the male assemblage, some of the younger men rack up the tortoises brought in that day. In the men's house, stories of the day's hunting, tales of past military adventures, deals with FUNAI officials, and even





arguments about inflation of the Brazilian cruzeiro continue well into the night.

At night back in the village, respected Kayapó elders customarily saunter about the central plaza, telling stories and lecturing people to be good to each other. On trek some of the less prestigious elders try their hand at this traditional oratory. Sometimes they are laughed down, but they may gain enough respect to continue their haranguing in the main village. The men seated in the men's house often seem to ignore the elders' preaching, but occasional comments and questions reveal the audience's attentiveness. Later, loud hoots from the men's house signal the breakup of the meeting and the end of the day.

While this pattern of ceremonial trekking is still most common, the Mekranoti recently have begun to alter their wandering strategies. More frequently, only the men go out to collect tortoises. Women are reluctant to expose their children to the dangers of the forest and to abandon the medical services that a resident FUNAI nurse offers. The men also seem somewhat reluctant to go on trek. Many of them attempt to excuse themselves by complaining of sickness and injuries, but eventually they find themselves cajoled into joining an expedition. When only the men go out looking for tortoises they may divide themselves into their men's societies—the Mekranoti village has two such civic political fraternities—and take off in two directions. If the women and children do not accompany them, the men travel much faster and are certain to return sooner.

But regardless of who does the trekking, the last few days of a Kayapó ceremony remain the same. As the women and children go on ahead to the main village, the men stay in the forest to paint their bodies and prepare the racks of tortoises for a grand procession into the central plaza. After delivering





Far left: At the village, men assemble live tortoises, which they have gathered on trek, to deliver to the ceremony's sponsors. Left: On trek, men carry tortoises on racks from one camp to the next. Below: A village elder helps butcher tortoises.



this heavy cargo to the ceremonial sponsors, the men proceed to the men's house or to their own homes where the long process of body decoration begins. Having bathed, everyone in the village is first painted with black, long-lasting, genipap dye. Red urucú mixed with palm nut oil follows, giving the Indians' skin an attractive sheen.

After these initial preparations, Indians who have inherited the privilege add ornaments—eggshells or feathers glued on the body, intricate headdresses, necklaces or bracelets. Once decorated, the Mekranoti spend most of the final days of a ceremony showing off their finery in periodic processions around the men's house. Usually, an exhausting all-night parade around the village—complete with singing, the rhythm of rattles, and stomping dances—brings the ceremony to a dramatic close.

Although most treks are ceremonial, the Mekranoti, who spend about a quarter of their time out on trek, also take to the forest for other reasons. Usually they cite some locally unavailable, but essential, item as a reason for a non-ceremonial trek, but there are other excuses, such as friendly visits to relatives in neighboring communities, which may be as far as 150 miles away. Generally, the daily routine of these treks resembles that of the ceremonial journeys.

The most important distinction between the two types of treks has to do with community relations. Normally, when in the village, married men live with their wives' extended families. When out on non-ceremonial treks, a man will travel with this same set of relatives. On ceremonial treks, however, people sleep next to a very different group. The night before such treks, the male sponsors, of whom there is always more than one, go to the men's house and call upon their male relatives, both real and fictive (through choice or inheritance), to help them collect the tortoises needed to climax the ceremonies.

The process looks very much like a choosing up of softball teams. Husbands are accompanied by their wives and children. Since everyone has a different set of fictive kinsmen, every ceremonial trek puts families together differently—a novel way for tribesmen to become better acquainted with their fellows.

While I was in the village, about half the population took off on a three-month trek in search of palm nuts for hair oil, while the other half spent a few weeks traveling to a larger river to fish. Another trek fetched a kind of resin that the women needed to paint designs on children's shaved heads. All of these expeditions lasted at least several weeks, but there were also shorter trips away from the village. Individual families often took off for a few days to get meat. Several times, the men left the village to collect masking materials or to chase herds of peccaries. These shorter trips were not like treks because they did not involve carrying garden produce. But the longer excursions were every bit as difficult as the ceremonial treks.

Since the Mekranoti so willingly expend great energy carrying around garden produce, trekking must provide benefits greater than a few bottles of hair oil. Recently, some anthropologists have argued that trekking, where it occurs, is a response to meager sources of protein. Although the Amazon River and some of its major tributaries are renowned for their generous stocks of fish and the richness of the surrounding wildlife, this great natural wealth is not found in the remote areas of the Amazon Basin away from the fertile flood plains of the major rivers.

Where the Mekranoti live, fish and game are relatively scarce, and garden products—sweet potato, banana, manioc—are notoriously low in vegetable proteins. While they are a good source of some proteins, Brazil nuts alone, or in combination with starchy produce,





Left: For a couple of months before a trek, an occasional ritual signals that a ceremony is in progress. Below left: During the festivities at the end of a trek, villagers form a procession. One mother carries a child with a heavy feather headdress. Below: During the very last moments of a festival men hide under leaves, preparing to grab masks that they will hoist on poles to mark the ceremony's end.





cannot supply the Mekranoti with the proteins that only animal sources can provide. The Kayapó must roam over great distances to capture game to satisfy their basic dietary requirements. Trekking is necessary, regardless of the work required.

While in the village, Indians eat meat about six out of ten days, but on trek this average climbs to about nine out of ten. This difference is due largely to the greater amount of time hunters on trek spend searching for game. When living at home, men hunt about nine hours a week, but out in the forest this average soars to twenty-eight hours a week. Hunters bring back game on about half the days they go out. This figure remains the same on trek and at home, even though competition over a day's hunting territory is much greater while on trek. And so considerably more meat is captured and consumed while traveling out in the forest. Thus far, this procurement strategy has protected the Mekranoti from protein deficiencies, but their nutritional future may depend on continuing freedom to wander over large tracts of land.

Although protein plays an important role in the origin of Mekranoti trekking, it cannot explain why these Indians did not try to reach game in easier ways. They could have simply spread out, planting gardens and building houses



throughout the jungle. Then each family could live off the resources of its own local territory. But the Kayapó prefer to live in large villages where trekking is the only way to reach scattered wildlife.

Perhaps the desire to stick together comes from the tradition of Kayapó warfare. The Mekranoti explain the raids they carried on before 1967 as a means of revenge, looting, or kidnapping. (One old Brazilian man, a middle-aged Tapirapé woman, and three young Kreen Akrore who were kidnapped as youngsters still live in the Mekranoti village.) Although the Mekranoti have calmed down in the last ten years, they are periodically subject to fears that some day the Kreen Akrore will return to avenge the 1967 raid.

In the past, when such fears were stronger, the village often moved to a more distant, safer location. This terror of enemy retaliation accounts for the Kayapó desire to congregate in large villages rather than dispersed residences. Fear may also have been responsible for the Mekranoti's former reluctance to send only men out on treks, leaving the women defenseless. As cooperation replaces violence between Kayapó and other peoples, trekking habits may give way to other adaptations to the tropical environment.

Although protein scarcity and warfare may account for Kayapó trekking, they do not explain why the Mekranoti remain together when they trek, while their relatives in the savanna regions of central Brazil break up into smaller groups at these times. Mekranoti men on trek must compete for hunting territories, while savanna groups send hunters off in different directions. The Mekranoti have failed to adopt this easier method because they are unable to use the small local streams, which are choked with water plants and dead trees; thus, they are obliged to travel overland. Anyone who has waded for hours through knee- to waist-high waters can appreciate the work required to hack a path through lowland tropical forest. Since the Mekranoti spend almost two hours a day transporting bundles alone, a good path is of utmost importance. By traveling together, the Mekranoti can save time cutting trails. Although the Mekranoti have to keep hunters in the same area, this disadvantage is easily offset by the work saved on path making.

Three factors—protein scarcity, warfare, and difficulty of transportation—have dictated the Mekranoti style of trekking. Today, game is still dispersed and the making of paths is as difficult as ever, but warfare has disappeared. Now, before organizing an excursion, the Indians take into consideration such new factors as government-sponsored medical services and the sale of Brazil nuts to FUNAI. Nevertheless, as long as treks provide basic needs, the Mekranoti will keep traveling. □

The Mekranoti chief, above left, dresses for a festival in genipap dye and inherited ornaments. During the last days of a ceremony, young women, painted and adorned with eggshell ornaments, right, gather at the house of the ceremonial sponsor.



Beware: Nonpoisonous Snakes

by Sherman A. Minton, Jr.

Many species formerly thought harmless to humans are inflicting some nasty bites

During the summer of 1957, I collected a slender, three-foot-long green snake near a rural hospital in Costa Rica. On my return to the United States, I gave the snake to a friend, also a physician-herpetologist. A few nights later I received a phone call from him.

"About that snake you gave me, are you sure it's harmless?"

"Well, I'm sure of the identification, and all the books say so."

"I'm glad to hear that because it bit me a few minutes ago, and my hand's beginning to swell."

Unable to think of any sensible plan of action, we did nothing. In a few hours the swollen hand returned to normal, leaving us relieved but puzzled.

The snake was *Leptophis ahaetulla,* a member of a well-known genus of tropical American tree snakes sometimes called parrot snakes. They are classified as aglyphous colubrids, a loose, hodgepodge grouping of snakes whose teeth are not grooved or otherwise modified for injecting venom. The scientific world has always considered snakes of this type harmless to humans.

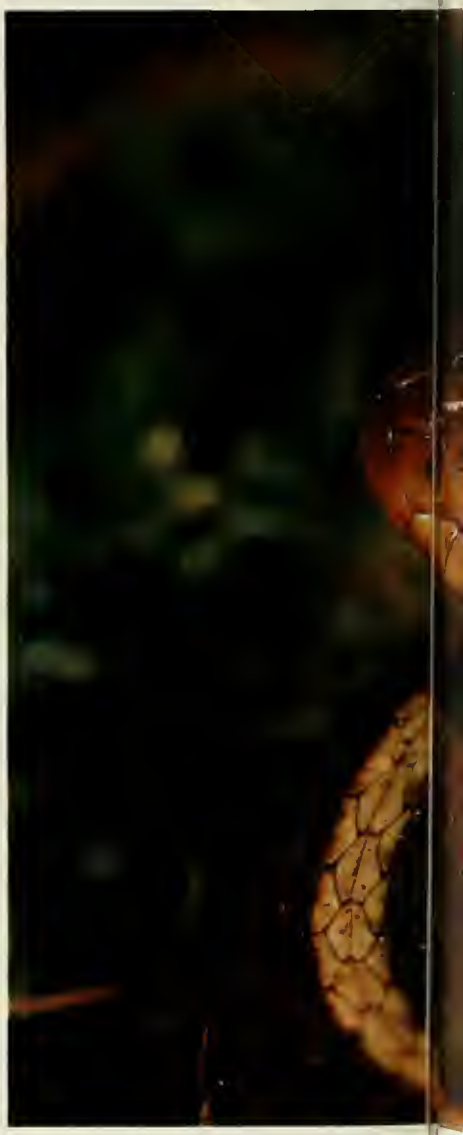
There is a growing body of evidence, however, that this is not always so. In 1960 the late Arthur N. Bragg, a herpetologist best known for his studies on spadefoot toads, reported pain and swelling of his hand, lasting several days, after he had been bitten by a western hognose snake. In 1973 a sixteen-year-old boy had similar symptoms after being bitten by an eastern hognose snake. Hognose snakes are considered not only harmless but also exceptionally inoffensive; Bragg therefore believed the bite was a feeding rather than a defensive response, since he had been handling frogs just before he was bitten.

In 1954 and 1966, West Indian racers were incriminated in cases of envenomation (fang punctures, with local or general signs of venom having been injected), one of them accompanied by swelling that spread to the entire arm. During this period, there was also a report of mild envenomation by *Ahaetulla papuae,* an arboreal snake of New Guinea, and another of a venomous bite by a parrot snake from western Mexico. These colubrids had all been considered harmless.

The most serious cases of poisoning by a colubrid have been caused by a plentiful and familiar snake of the Far East, *Rhabdophis tigrinus.* In some regions of Japan, large numbers of this snake, known as yamakagashi, are used for food.

My first intimation of this snake's venomous nature came from a report sent me in 1969 by a California physician. His patient, an amateur snake keeper, had been bitten on the finger while offering food to a captive snake. Within a few minutes his finger swelled and he developed a severe headache. Later, his gums began to bleed; bleeding from a small razor cut could not be stopped; he had pain over his kidneys; and there was blood in his urine. These alarming symptoms subsided about forty-eight hours later. In my reply to the physician, I wrote, "The case report . . . is downright spooky. Assuming the facts, including the identification of the snake, are correct, it is unique and very hard to explain. It is the most severe case I know of apparent envenomation by a colubrid without rear fangs."

A few years later, herpetologists M. B. Mittleman and R. C. Goris reported two serious cases of yamakagashi envenomation from their own experience, plus a third case reported in 1932 in a provincial Japanese medical journal. The most striking features of these cases were the loss of the normal clotting



Common to much of North America, the garter snake is considered to be innocuous. But a California youngster was hospitalized after being bitten by one.

power of the blood and resultant hemorrhages. The patients recovered, but their illness was as severe as that caused in many cases by the bites of rattlesnakes and other unquestionably venomous species. Japanese workers have recently reported other severe yamakagashi bites and are generally cautious in handling the snake.

Meanwhile, reports of poisoning by other presumably nonvenomous colubrid snakes continue to come in. A Russian herpetologist has reported two cases of envenomation by a mountain racer, *Coluber ravergieri,* a widely distributed snake of western Asia and the Middle East. A few years ago I was called by a herpetologist who was having severe pain and swelling following the bite of a large South American snake sometimes known as cobra de Paraguay. In 1975 newspapers throughout the nation carried accounts of a California youngster who had been hospitalized following the bite of a garter snake. I talked with one of the physicians involved in the care of this patient, and we agreed that envenomation was the most likely explanation for the symptoms observed.

In all these cases, the question must be asked, Is this truly a case



Breck P. Kent; Animals, Animals

of venom poisoning? Infection is possible in any wound where the skin is broken, but in these cases symptoms developed much too quickly for bacteria or fungi to have multiplied and caused disease. Bragg proposed, and then refuted, the idea that his symptoms might have arisen from amphibian skin toxins that were on his hands or on the snake's teeth. Because most of the persons who have had apparently venomous bites by nonvenomous snakes have been herpetologists or others who have been repeatedly bitten by snakes, there is the possibility that some sort of allergy to snake saliva is involved. In some instances this could explain a few of the symptoms; but others, especially hemorrhages and nonclotting blood, are not usually manifestations of an allergic reaction. The most logical hypothesis that remains is that bites of a variety of snakes traditionally considered nonvenomous may be followed in certain cases by symptoms of venom poisoning.

The realization that it is no longer possible to make a clear-cut distinction between venomous and nonvenomous snakes is a matter of practical concern for those who work with snakes and those who must diagnose and treat snake bites. A fundamental question of the evolution of venom in snakes is also raised.

Although many snakes do engulf small prey alive, their success as limbless reptiles depends to no small degree on their ability to attack and subdue larger animals. To do so, they have evolved two basic methods—constriction and injection of venom. Constriction is presumably the phylogenetically older method since it is used by the primitive boas and pythons, and no evidence of venom has been found in this group of snakes.

An alternative to constriction is the evolution of highly toxic oral secretions and an effective mechanism for injecting them. Hollow or deeply grooved fangs and specialized venom glands have evolved in three lines of snakes: one comprises the widely distributed vipers



Jack Wilburn; Animals, Animals

and pit vipers with long and highly movable fangs; a second includes the cobras, mambas, coral snakes, and sea snakes with generally shorter, less movable fangs; and a third, small group is made up of the mole vipers whose long fangs are used one at a time in a stabbing manner. There is no question as to the venomous nature of these snakes, although by no means are all dangerous to humans.

This leaves some 1,400 species of snakes of the group known as colubrids in which venom apparatus of varying degrees have developed. In some of these snakes, one or more pairs of grooved teeth in the rear of the upper jaw are associated with a well-developed venom gland. A few of these snakes are unquestionably dangerous; indeed, two eminent herpetologists are among their victims. In 1957 the bite of a boomslang, an African tree snake, killed Karl P. Schmidt of Chicago's Field Museum, and in 1975 Robert Mertens of the Senckenberg Museum in Frankfurt am Main, West Germany, died from the bite of another African tree snake, the twig snake.

Other species with this sort of venom apparatus, such as the mangrove snake, Natal black snake, culebra de cola corta, and mboi-obi, have inflicted venomous but nonlethal bites on humans. Most other colubrid species have a clear record, although some are regarded with suspicion since their venom is quite effective in killing prey.

Enlargement of teeth in the rear of the upper jaw without the presence of venom-conducting grooves is characteristic of many colubrid snakes. Among species that have teeth of this sort are the hognose snakes, the parrot snakes, the yamakagashi, and the West Indian racers. Other colubrids, such as the African house snakes and south Asian wolf snakes, have enlarged but ungrooved teeth in the front of the upper jaw; still others, such as the North American rat snakes and king snakes, have teeth of fairly uniform size. The feeding habits of snakes suggest that long teeth in the front of the upper jaw may be an advantage in capturing feathered or scaly prey such as small birds and lizards; long teeth in the rear of the jaw are better for holding less agile but more tenacious prey such as amphibians or other snakes.

Most of the venom in colubrid snakes seems to be secreted by Duvernoy's gland, located in the upper lip or at the angle of the mouth. This gland was found in 163 of 180 species examined in a study by Aaron Taub; however, there was considerable variation in its size and structure even among closely related species. Very little is known of the chemistry of colubrid venoms. Some are known to contain enzymes, such as phospholipase A and arginine esterase, that are common in the venom of poisonous snakes. Boomslang venom interferes with blood clotting and causes hemorrhaging by much the same mechanism as many viper venoms. Saliva of the yamakagashi seems to have the same effect. Saliva of the West Indian racers has the properties of weak viper venoms.

My studies on boomslang venom indicate the presence of at least five protein components, some of which are in the venom of many pit vipers. A neurotoxin similar in action to the α-bungarotoxin in the venom of the krait (a highly poisonous elapid) has been reported in the venom of Blanding's tree snake (a colubrid). While the biochemical evidence is ambiguous, the typical signs of colubrid poisoning in man—pain, swelling, and hemorrhages—are more like the symptoms of viper bites.

A baffling aspect of colubrid poisoning is the lack of close relationships among the incriminated species. The snakes come from every continent except Australia, which has few colubrids. The two most dangerous species, the boomslang and the twig snake, are African tree snakes that some authorities consider closely related, but their presumed Asian relatives, tree snakes of the genus *Dryophis*, have never been reliably identified as causing human injury.

The yamakagashi belongs to the group of natricine snakes that are the dominant snakes of the Northern Hemisphere (except in highly arid regions). Until quite recently, it was included in the genus *Natrix*, along with such familiar and widespread species as the banded water snakes of eastern North America, the European grass snake, and the checkered keelback, or paddy snake, of southern Asia. The North American garter snakes are also close relatives. Many of these snakes bite readily if disturbed, yet

Unquestionably dangerous, the green mamba, left, has movable fangs that are modified for the injection of a highly toxic venom. The parrot snake, below, is not similarly equipped, so this tree-dwelling colubrid of the American tropics had been thought harmless to humans. No more.



Paul A. Benson; Animals, Animals

only the yamakagashi has caused serious poisoning. The California garter snake bite case, however, indicates that some other species may be venomous to an extent. There are also some bits of evidence, morphological and biochemical, that hognose snakes are somewhere on the evolutionary line that produced the vipers. Venomous saliva has apparently evolved in several lines of colubrid snakes.

Prior to about 1950, there were very few reports of colubrid envenomations in the medical or herpetological literature. Since then they have been increasing steadily. I attribute this, first, to the great increase in the number of persons who keep and handle snakes as part of their professions or avocations. Nearly every reported case of colubrid envenomation has involved handling a snake in captivity or catching it by hand in the field. With the possible exception of the boomslang, colubrids must hold on an appreciable time (several seconds) in order to inject venom. The sort of quick defensive bite inflicted by a snake that is accidently stepped on or brushed against would not result in envenomation. Also interesting is that in at least a couple of serious colubrid bites, the snake was being offered food. Perhaps a bite stimulated by the presence of food is more likely to cause venom injection than one stimulated by fright or anger.

Another factor is the increasing availability of exotic snakes in the United States and Europe. A majority of colubrid bites have been caused by tropical species that were not generally available, particularly to amateurs, until fairly recently.

Although most of these bites involve nothing worse than a few hours of discomfort and some anxiety, the potential for serious trouble exists with a few known species, and the list is probably not complete. Medical advice should be obtained whenever a person develops unexpected symptoms after being bitten by a supposedly nonvenomous snake. A physician can discover evidence of internal hemorrhage, abnormal blood clotting, and other warnings of severe poisoning and take measures to counteract them. Nevertheless, treatment of severe bites remains far from satisfactory. No antiserum is available for most colubrid snakes, and significant cross-protection with antivenins for pit vipers and other unrelated snakes is doubtful.

The first snake I ever saw was a garter snake my father killed near the small southern Indiana town where I grew up. My father belonged to a generation that killed all snakes on the assumption that even if they were not poisonous, they could not be distinguished from kinds that were. I don't advocate a return to that attitude, but I would suggest a little more caution in handling reputedly harmless snakes. □



Zig Leszczynski; Animals, Animals

In response to a threat, an eastern hognose snake, left, "plays dead." Considered an exceptionally inoffensive, nonpoisonous species, a hognose nonetheless bit a boy who suffered pain and swelling for several days. The bamboo viper of Asia, right, has a pair of long, hollow, venom-injecting fangs that can inflict a fatal bite.

Zig Leszczynski; Animals, Animals





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Where "Mabel" May Mean "Sea Bass"

by Jack Stuster

photographs by Stephen Frisch

Some West Coast fishermen form offshore radio networks to share encoded information about fishing conditions

Always in a vulnerable economic position, independent commercial fishermen on the West Coast of the United States frequently modify their traditional values of competition, individualism, and self-reliance when they are at sea. Many form cooperative networks to share information about fishing conditions. These alliances take several different forms, and the type of fishing that crews do and the technologies that are available tend to affect the amount and type of cooperation. Not all fishermen who try to acquire information about fishing grounds do so with great success. Yet many of the more successful crews find up to one-half of their total catch on the basis of information transmitted by radio, either from intercepted or deciphered calls or from calls by fellow members of organized groups.

The fishermen least likely to share information at sea are those who catch fish in stationary gill nets or with set lines, or who trap crabs and lobsters. Although the territoriality and the suspicion of the New England lobstermen are not duplicated by West Coast trappers, competition for fish and for bait is equally severe. Each season has its quota of accusations—often justified—of stealing from traps. The proliferation of "trap barons," fishermen with as many as 500 traps, contributes to the rancor.

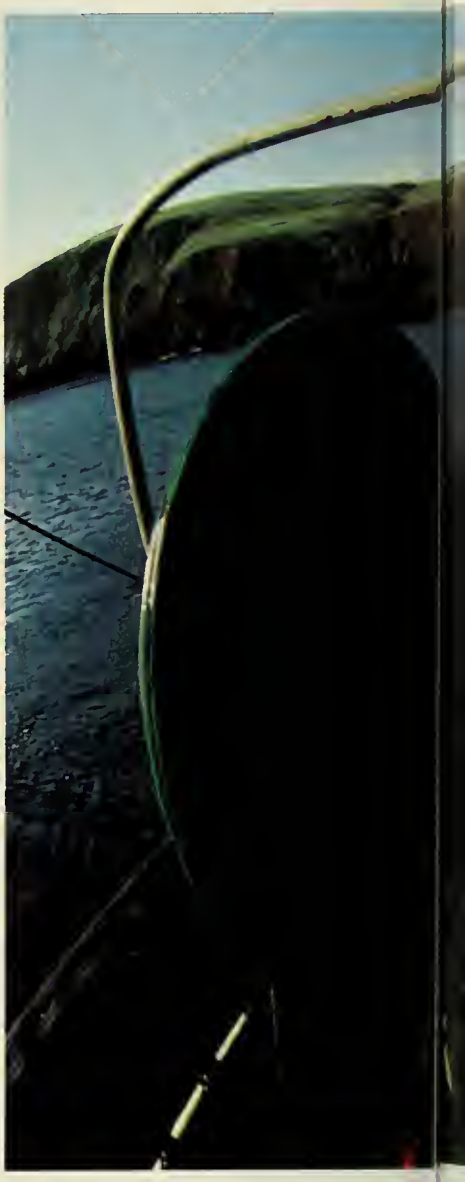
California's trapper fishermen work alone. Although some fishermen may hunt down concentrations of bottom fish in drag boats (called trawlers on the East Coast), most skippers tend to minimize their risks by fishing over relatively smooth, sandy bottoms rather than dragging their nets over potentially more productive, yet gear-destructive, rock piles. They match this conservatism in strategy with a minimum of talk about fishing conditions, both at sea and ashore, although skippers enjoy friendly conversation over the radio or on the pier about nonbusiness matters.

Trapper strategy fishermen take great care to preserve the secrecy of a "hot spot," to the point of practicing deception. Asked why he is working the same area so persistently, a dragger skipper may answer that he is trawling for a lost net. When he lands a full load of fish the next day, he may excuse himself by claiming an exceptionally lucky tow over a ground well known to all crews. Trappers may talk vaguely of fishing "up the coast" and "down the coast" if fishing is poor. They may give out misleading or, at best for their competitors, no information. A dragger that had been consistently landing large loads of sole was followed to its grounds by another vessel. When the crew of the first boat dropped nets into the water, the second crew quickly followed suit. For the next hour, the two draggers continued slowly on the same course until the lead boat quickly



A dragger with white sea bass and leopard sharks, left, runs by Santa Cruz Island. Right, a fisherman uses one of many radios available for communication offshore.





Trapper strategy fishermen tend to be more individualistic than hunters, rarely sharing information about fishing conditions. The trappers include shellfishermen, above, and gill netters, who set stationary nets, right.

retrieved its nets, which were just below the water's surface, and sped away. By the time the deceived crew had hauled in their gear from a depth of 400 fathoms, the lead dragger was beyond radar range and could not be traced.

Lack of cooperation among these crews is both common and understandable, since their primary concern is to protect the secrecy of rich grounds. Hunter strategy fishermen, however, often have good reason to exchange information about fishing conditions on the water. These crews troll with nets or stalk with hooks or harpoons, literally hunting down migratory schooling fish, such as sea bass, salmon, albacore, and swordfish. These fish appear in coastal waters with limited regularity and predictability over a period of time as short as a month and an area as large as several thousand miles. Since a boat can be in only one place at a time, a fisherman who shares information with other boats has an advantage over a crew that works independently.

The recent development of excellent electronic equipment has facilitated sharing of information at sea. Depending upon the scope of the fishing enterprise, a vessel may carry as many as eight radios and electronic navigation devices. These include single sideband, VHF, AM-band, and citizens' band radios, as well as radio direction finder, depth sounder, Loran, and radar. Some boats also carry spare gear for each instrument. Speakers for the radios are located in the pilothouse and on deck so they may be monitored continuously by the skipper from all working stations.

Use of this electronic equipment has allowed the development of three kinds of cooperative arrangements among West Coast hunter strategy fishermen. Two affiliation groups are formal: one, which fishermen call a "code group," involves between two and twenty vessels, and the other, referred to as a "running partnership," involves two vessels. The third group is an ad hoc communication relationship between two vessels at sea.

In a code group, about a dozen boats seem to be the optimum size for maximum solidarity and information sharing. More boats, all converging on one "spot of fish,"



could force a school to sound or scatter. Members may be distributed over as much as 50,000 square miles of open sea. The primary purpose of the grouping is to share exclusive information concerning fishing conditions. A well-structured, long-standing code group might include twelve medium-to-large albacore trollers from different ports. Their skippers, good friends over the radio, may not know each other face to face for several seasons. Boats have code names, such as "Lord Nelson," "Gramps," or "Fish Wagon," and each skipper possesses a closely guarded glossary of the codes used in communications, including a schedule of hails, or calls, that could be made or expected.

The members are obliged to share all information about their catches and fishing conditions, and they are expected to pass along information obtained by monitoring the radio transmissions of vessels not members of the code group. Using nonmembers in this way allows the group to cover a wide area with no waste of time. Secrecy is all-important, and security measures may include codes, scheduled calls on preselected radio channels, and the use of exotic radio frequencies, foreign languages, and scramblers, which garble a transmission for everyone except the intended receiver.

The codes may take several forms. The message, "Mabel wants you to go to an anniversary," might mean that sea bass ("Mabel") are running off Point Conception ("an anniversary"). A group might mislead nongroup members by transmitting catch figures that are an agreed upon fraction of actual figures. A message such as "We're going to eat spaghetti tonight" could indicate a successful catch. Italian- or Portuguese-speaking fishermen often use their language or a dialect, and foreign languages





The location of the transmitting vessel must be given if the information is to have any value to the receiving vessels. This position may be given circuitously, for example, "I'm 100 miles south of where I was three days ago when we talked" or "I'm where we had those 300-fish days two seasons ago." At times, the position is given in code, which might mislead crews not in

Code groups, running partnerships, and ad hoc communication networks are important to swordfishermen, who must literally hunt down their prey, fish by fish. Knowing where fish are running greatly increases chances of a successful catch.



are also spoken on shore both by fishermen and by fish buyers to limit eavesdropping. Use of a foreign language sometimes may be counterproductive. One particularly successful swordfish hunter, of whom it is said, "He even considers the time of day to be a secret," rarely exchanges information with vessels other than those owned by his brothers and son. But other fishermen know that when he is speaking Portuguese on the radio, chances are that he has found good fishing. A generation ago, the primary languages on the northern California fishing grounds were Italian and Portuguese, but these languages are now generally used to impose secrecy. Fewer sons of old-time fishermen are going to sea, and in recent years, recruits to West Coast fisheries have increasingly been the college-educated sons of English-speaking, middle-class families.

the group. Other crews could attempt to locate the transmitting vessel by homing in on it with their radio direction finders, but an RDF cannot determine distance. Conceivably, two or three nonmembers could cooperate and take bearings from different known locations in order to get a fix on the transmitting boat.

"Running partners" are two boats that usually hail from the same port, although vessels from different ports might rendezvous on their way to the grounds. These alliances typically are made on the basis of friendship, usually between fishermen of equal ability. The primary goal is to share information on the whereabouts of fish, but the running partnership is also useful as a safety measure when fishing offshore, especially when vessels are "running" between major concentrations of fishing fleets.

Unlike members of code groups, who come together briefly to fish runs, or "hot spots," and then disperse to hunt for fish schools elsewhere, running partners tend to fish in proximity for an extended period of time. Some fishermen fish with the same partners for years at a time; others switch partners several times a season. Running partners are usually members of the same code group.

A few hunting strategy fishermen prefer to fish alone either all or part of the time, and at sea they rarely communicate with other fishermen. Some may engage in offshore information sharing that is not as well organized as that in code groups and running partnerships. I once overheard the following, unplanned converstion between two northern California salmon trollers. A fisherman hailed a friend in Italian one evening and after giving his location and discussing personal matters, he said (still in Italian), "We're getting ready to make some wine. The grapes are ripe and if you want to pick up some barrels, you'd better get up here."

Masked by the preceding trivia and by the reference to "wine making" was the valuable information that the speaker's crew had been catching a quantity of large salmon—since only the largest fish are split and packed in barrels by buyers to be processed into lox. Understanding the message, the second fisherman ran all night up the coast and caught more than $1,000 worth of salmon the next day. What the ad hoc affiliates may





Trimmed of their tails, fins, and jaws, swordfish are pulled from holds at the Santa Barbara wharf. Cooperation between fishermen usually ends when their boats dock.

lack in structure and continuity, they make up in creativity and spontaneity.

Actually, only a small percentage of the total volume of radio transmission between fishing vessels at sea contains valuable information. The successful fishermen are those who develop working, cooperative networks and who have a highly developed capacity to filter out significant information from the constant barrage of trivia. Their radios, equipped with scanners that automatically search the bands for transmissions, blare out hundreds of conversations over deck and pilothouse speakers. Information is often detected by fishermen sensitive not only to what is being said but also to who is talking and the speaker's tone of voice. Identifying the fisherman is important in judging the veracity of the information. The tone of voice might indicate the conditions near the vessel—a speaker who is short of breath, for instance, may be working hard in a school of fish. Some fishermen, listening to the many hours of transmissions concerning weather, equipment, family, and friends, never do develop the proper interpretive skills. These people exuberantly chase illusive "radio fish" all season long.

The hunter's reliance upon, and the trapper's rejection of, cooperation are both rational choices based upon the nature of their fishing strategies and technologies. It is in the hunter's self-interest to share information about fishing conditions, just as it is in the trapper's self-interest to be secretive about grounds. But on shore, both types of fishermen are reluctant to cooperate. Individualism, apparent thinning out of fish resources, and occupational hazards contribute to competitiveness between fishermen in the unstable marketplace. Buyers frequently have employed collusion, price fixing, retaliation, and indenturing loans to keep fishermen in a vulnerable economic position. For these reasons, cooperative activity on the beach is of a different order from what it is at sea. □



The Triumphant Trumpeter

by Paul A. Johnsgard

Once reduced to a few bevies, this magnificent swan is on the road to recovery

Largest of all the swans and heaviest of North American birds, the trumpeter swan is on the increase. Once common and widespread over much of the western United States, the bird was a winter resident of the lower reaches of the Mississippi Valley, Louisiana, and Texas. During the last century, however, trade in swanskins—used to make powder puffs and writing and drawing quills—and the sale of eggs to collectors had a heavy impact on the species. In the period from 1853 to 1877, for example, London sales of trumpeter swanskins imported through the Hudson's Bay Company totaled nearly 18,000, an average of about 750 per year. Destruction of their prairie habitat and increased disturbance also took a heavy toll of these shy birds. By the time the species came under the complete protection of the Migratory Bird Treaty Act in 1918, many ornithologists believed that the species was doomed to extinction.

Population surveys in the early 1930s gave estimates of from 37 to 97 surviving trumpeter swans, nearly all of them in Yellowstone National Park and the nearby Red Rock Lakes area in southwestern Montana. At that time, a large breeding population in Alaska was overlooked because it was believed that those birds were whistling swans, a species closely related to the trumpeters. Since the realization in 1954 that trumpeter swans nested in Alaska, surveys have indicated that there are now at least 3,000 in that state. In addition, about 150 trumpeters survive in the marshes of western Alberta.

But in the 1930s, conservationists did not know how many birds existed north of the Canadian border, and the outlook for the species within the contiguous United States was grim.

The establishment of Red Rock Lakes Migratory Waterfowl Refuge in southwestern Montana in 1935 was doubtless the most significant factor in protecting the last remnant of breeding trumpeter swans south of Canada. The nucleus of birds at that refuge provided other parks and refuges with trumpeters to establish new flocks. The first such transplant was conducted in 1938, when four cygnets were placed on the National Elk Refuge, near Jackson, Wyoming. Six additional birds were released there in 1939 and 1941, and the first breeding occurred in 1944. Thereafter, nesting took place nearly every year, although no more than two



A pair of trumpeter swans has colonized one of the mountain lakes in Grand Teton National Park. Unfortunately, the lake is more suitable for the breeding of other waterfowl, foreground.



Jonathan Wright, Bruce Coleman

Paul A. Johnsgard



Trumpeter swans fly over Grand Teton National Park, possibly in search of waters suitable for nesting. During a recent six-year period, the swans nested at eight sites within the park.

nests were ever reported in any single year.

Presumably from these nestings, trumpeter swans colonized abutting Grand Teton National Park a few years after its establishment in 1950. (The protection from disturbance by ranching and other, related activities formerly in the area probably made colonization possible.)

One of the first areas to be occupied was Christian Pond, a thirty-acre marsh near Jackson Lake Lodge. Breeding occurred on that pond as early as 1954, and nesting attempts have been made every year since. During the eight-year period from 1969 through 1976, at least eighteen cygnets were raised by a pair using Christian Pond. Whether the same pair was involved every year is not certain, but it is possible: swans are long-lived; some have survived in captivity for more than thirty years.

Other areas in the park have also been used by trumpeter swans for nesting. In the six-year period between 1970 and 1975 a total of eight different sites had nests. Yet during that entire period only forty-three cygnets are known to have been reared, including those from Christian Pond. Considering that the usual clutch is four to six eggs, the reproductive success of the seven known pairs in the park each year was extraordinarily low; the average for all pairs was less than one young successfully raised per year.

Trumpeter swans have now been breeding in Grand Teton National Park for at least twenty-five years; yet the number of breeding pairs has not increased measurably in the last ten years. The question that arises is, What could be responsible for this bird's low reproductive rate and nonincreasing population in the park?

The reproductive potential of the trumpeter swan is typical of swans in general and might be considered a model for large waterfowl. Although some refuge-raised trumpeters have bred when they were approaching the end of their third year, wild birds often do not breed until their fourth year as a result of competition for suitable nest sites with older and already established pairs. Thereafter, the birds attempt to nest every year for as long as they live. The survival rate for trumpeter swans in the wild is still unknown, but in the related Bewick swan of Eurasia, it is about 85 percent per year. Likewise, the Eurasian whooper swan, often considered conspecific with the trumpeter, has an estimated annual survival rate of 83 percent. The potential longevity of trumpeter swans should result in a large number of offspring over their lifetimes. Why then is Grand Teton National Park not afloat in trumpeter swans?

To answer that question, one must examine not only the environment in terms of its carrying capacity for swans but also the efficiency of the swans' reproductive efforts.

Studies on the biology of trumpeter swans indicate that their reproductive needs are fairly simple. Territories of breeding pairs are almost always large to insure an adequate food supply for the adults and as many as six young. Rarely is a territory established on a pond or lake of less than five acres, and in Grand Teton National Park, as well as at Red Rock Lakes Refuge, the average territorial size is about thirty acres. Some marshes or small lakes as large as one hundred acres may be defended from intrusion by other pairs, particularly if the shoreline is open enough for unobscured vision. Both the white plumage and the extremely loud vocalizations of the trumpeter swan have apparently evolved as devices for proclaiming large territories by maximizing individual conspicuousness.

Other considerations besides a minimum water area are important in determining what constitutes acceptable nesting habitat. First, water levels should be stable, avoiding the possibility of the nest's exposure to territorial predators as a result of dropping levels or of flooding caused by a rise in water level. Second, much or all of the

water in a territory should be from one to three feet deep, to allow for subsurface foraging while swimming, and the water should be quiet and wave-free, with an abundance of emergent, floating, and submerged plants. The emergent plants are primarily of value as cover and as foundation material for the nest, while the submerged and floating plants provide an adequate food supply for these large herbivores.

Given these considerations, that Grand Teton National Park does not have more nesting swans is not surprising. Many of its waters are deep, clear lakes, formed by glacial action, that offer little food or cover for the birds. Christian Pond, however, as well as several of the other regular nesting sites in the park, is beaver formed, and its level is controlled by beaver dams. Like the moose, which feeds extensively on aquatic plants, and the greater sandhill crane, which nests in or around beaver impoundments, the presence of trumpeter swans in Grand Teton National Park is closely tied to the abundance and distribution of beavers.

A very high mortality of eggs or cygnets is the probable reason for the low reproductive rates. To avoid overestimating cygnet production, the National Park Service's annual count of swan families in the park is usually made in late August or early September, when the young birds are nearly fledged. Therefore, there has been no way of knowing if most mortality occurs prior to hatching or sometime thereafter. But during three summers spent in the park, I never saw a full brood of six cygnets and rarely saw more than two, even shortly after hatching. This would suggest that most mortality happens early, probably before the young are one to two weeks old. In any attempt to understand what the causes of such cygnet or egg mortality might be, the breeding logistics for a bird the size of a trumpeter swan have to be considered.

Trumpeter swans typically build large, mounded nests in marshes, well away from shore, in water about one to two feet deep. These nests are often constructed of bulrushes, cattails, or other emergent vegetation; at times beaver lodges or muskrat houses are also used. A week or more may be spent building a new nest or refurbishing an old foundation. Egg laying then begins and continues for ten days until a full clutch has been deposited. Incubation begins with the last egg and lasts an average of 36 to 40 days. Finally, the young birds have an extremely long fledging period, estimated at from 91 to 122 days in the Montana-Wyoming population. Thus, a minimum of 142 days, and perhaps as much as 173 days, are required from the time nest construction begins until the young fledge. Since the frost-free period in the Grand Teton National Park area is less than 80 days, the bird's long reproductive



H. Engels; Bruce Coleman

An adult stands over a cygnet on the mass of vegetation that serves as the nest. Material for nest building is gathered from the emergent aquatic plants surrounding the site.

J. Spurr, Bruce Coleman





Peter B. Kaplan

Although the early morning air temperature is subzero, two trumpeter swans, above, swim and preen in Yellowstone National Park's Firehole River, which is fed by warm springs. Right: Under prime conditions, trumpeter swans may raise up to six young annually. A long, frost-free period—at least 142 days—seems to be one of the key factors for a high reproductive rate.

cycle poses certain risks: the eggs might be fatally chilled before they hatch; the young cygnets might freeze before they develop adequate temperature regulation; and the water might freeze over before the juveniles fledge and thus lose their vulnerability to coyotes and other predators.

I believe this environmental factor is primarily responsible for the low reproductive success of trumpeter swans in the Grand Teton area. Originally adapted to breeding on prairie marshes in areas where the frost-free period is often 200 days or longer, trumpeters often succumb under the severe strains of breeding in montane areas. Even in southeastern Alaska, where the largest population of trumpeter swans now exists, the frost-free period is more than 120 days and thus far less likely to be a mortality factor. In Alaska, 80 to 85 percent of the cygnets survive at least to the age of two months.

If there is a lesson to be learned from this, it is that future releases of trumpeter swans into refuges should be done with some attention to the climatic characteristics of the area. A release in 1960 at Lacreek National Wildlife Refuge in South Dakota has been perhaps the most successful of the trumpeter transplants; the population there now numbers well over one hundred birds, and the swans have spread out and nested in ten counties in South Dakota and three in Nebraska. Limited releases have also been made in Minnesota and Nebraska. These areas have frost-free periods of at least 130 days.

There are now between 4,000 and 5,000 trumpeter swans all told. Without doubt, other refuges in the Great Plains could support breeding populations of this magnificent bird once its proper habitat—the remaining marshlands of the Great Plains, not some mountain lake—is recognized. □

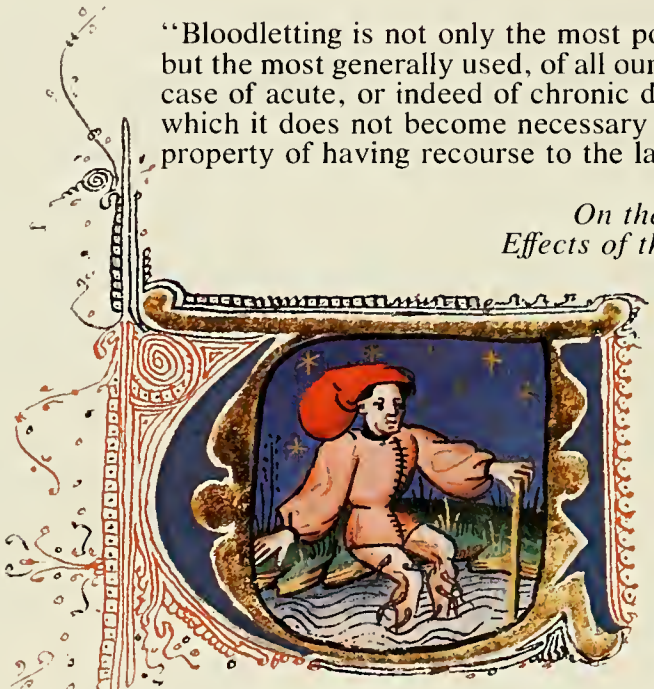


The History of Bloodletting

by Matthew J. Kluger

"Bloodletting is not only the most powerful and important, but the most generally used, of all our remedies. Scarcely a case of acute, or indeed of chronic disease, occurs, in which it does not become necessary to consider the property of having recourse to the lancet. . . ."

Marshall Hall
On the Morbid and Curative Effects of the Loss of Blood, 1830



Pierpont Morgan Library

I first became aware of Marshall Hall's thoughts on bloodletting about ten years ago, when I was investigating various aspects of hibernation in bats. Hall was the first investigator to observe, back in 1832, that many species of temperate-zone bats are capable of undergoing frequent periods of torpor, allowing their body temperatures to drift downward toward the environmental temperature.

A widely respected scientist who published papers on many subjects, Hall was capable of writing, "It sometimes requires no little boldness to abstain from the use of the lancet." Like most physicians and scientists of the early nineteenth century, Hall would have considered bloodletting an effective treatment for apoplexy, angina pectoris, asthma, vomiting blood, bruises, coughs, tuberculosis, contusions, diseases of the hip and knee joints, deafness, delirium and lunacy, dropsy, epilepsy, dizziness, gout, whooping cough, hydrocephalus, headaches, inflammation of the eyes and lungs, drunkenness, lethargy, lumbago, measles, numbness of the limbs, ophthalmia, pleurisy, palsy, defective perspiration, rheumatism, insomnia, sciatica, shortness of breath, sore throat, and chest pains—among other troubles.

Western doctors' advocacy of bloodletting was firmly rooted in the Hippocratic doctrine of humors, which was based largely on the theory advanced by Empedocles, a Sicilian-born philosopher of the fifth century B.C., that the human body is composed of the four elements—earth, air, fire, and water. Other early natural scientists, especially Hippocrates in the fourth century B.C., expanded Empedocles' elements into the four humors of the body—blood, phlegm, yellow bile, and black bile. The humoral theory of disease maintained that illness occurred when the body produced one of the four humors in excess. Then the body's defenses came into action. The patient's elevated body temperature, or fever, "cooked" the excess humor, separating it from the other humors so that the body could eliminate it.

The physician could help the patient by performing two procedures. First, to assist the body in cooking the excess humor, the physician could warm the patient externally or give medicines that would raise the body temperature. This form of fever therapy has been advocated by physicians for thousands of years. For example, Rufus of Ephesus, a first-century physician, wrote, "I think that you cannot find another drug which heats in a more penetrating manner than fever; for this reason it is a good remedy for an individual seized with convulsions, and if there were a physician skillful enough to produce a fever, it would be useless to seek any other remedy against disease." Rufus advocated the use of fever as a therapeutic

agent for epilepsy, convulsion, tetany, asthma, melancholia, certain skin diseases, and other medical problems.

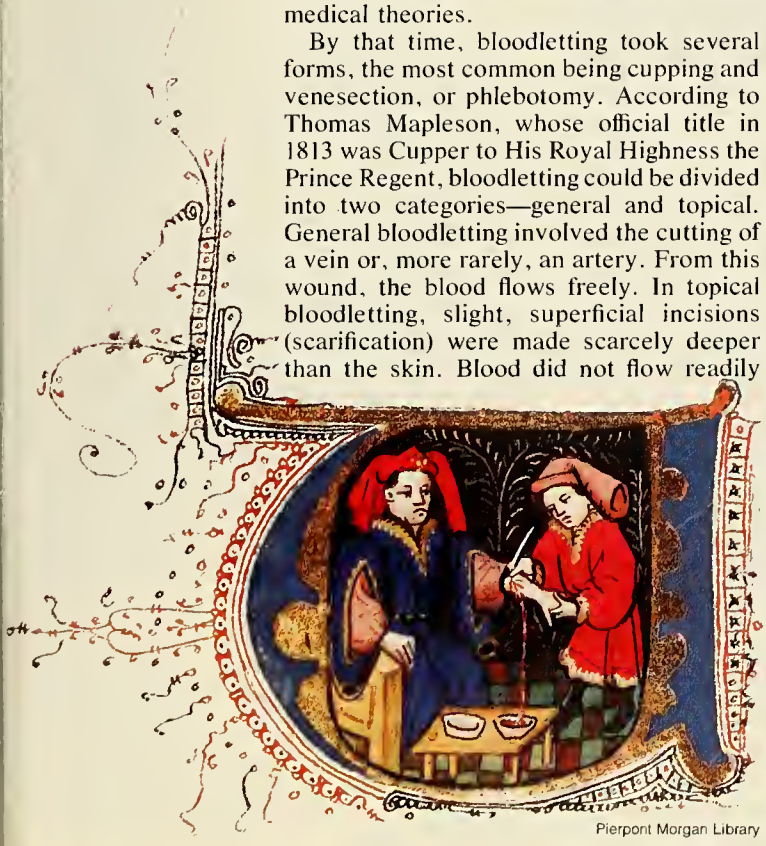
The second form of therapy available to the physician involved assisting the body to evacuate the cooked humor by purges that induced bowel movements, emetics that induced vomiting, sudorifics that induced sweating, or by bleeding. The humoral theory of disease greatly simplified the practice of medicine by reducing major classes of drugs to those which warmed, cooled, purged, and so on, and by narrowing major therapies that did not call for medicines to the regulation of external temperature and to the removal of blood. Because of the great influence Hippocrates and his disciples had on Western medicine, these practices continued throughout the Middle Ages and the Renaissance. Not until the 1800s did scientific investigators begin to actively scrutinize many of the ancient scholars' medical theories.

By that time, bloodletting took several forms, the most common being cupping and venesection, or phlebotomy. According to Thomas Mapleson, whose official title in 1813 was Cupper to His Royal Highness the Prince Regent, bloodletting could be divided into two categories—general and topical. General bloodletting involved the cutting of a vein or, more rarely, an artery. From this wound, the blood flows freely. In topical bloodletting, slight, superficial incisions (scarification) were made scarcely deeper than the skin. Blood did not flow readily from these types of incisions unless the physician applied some form of suction. Mapleson says that

> Hippocrates takes notice of two kinds of instruments for the purpose of eliciting blood after the operation of scarifying. The first a small gourd, or cucurbit, furnished with two orifices, one of a sufficient size to include the scarification, the other small; by applying the mouth to the latter, the air was sucked out, and a partial vacuum formed; it was then closed by means of a bit of wax, till a proper quantity of blood was obtained. The other, of similar form and size, was constructed of brass, but with only one aperture. In this a vacuum was produced by inserting a piece of burning flax or linen previously to applying it to the skin; a method very analogous to that which is employed for making a vacuum in the cupping glass at the present day. Hippocrates mentions also the application of exhausted cucurbits over the orifices made by leeches.

As in all medical endeavors, controversies arose over the efficacy of various treatments. Here the cuppers opposed the phlebotomizers. Blood obtained during phlebotomy is entirely venous. It has not reached the heart and is partly deoxygenated, having passed through body tissues, giving up nutrients and picking up wastes. On the other hand, blood collected by cupping generally consisted of a mixture of both arterial, or oxygenated, blood and venous blood. Mapleson, a strong advocate of cupping, said that "the crimson and purple color may be clearly distinguished as the two kinds of fluids mingle in the glass. I have observed that the more abundantly the arterial blood appears, the more benefit is generally derived from the operation." Others, including Benjamin Rush, a leading physician in colonial America, were strong advocates of venesection.

The amount of blood that was let varied but could be substantial. Patients commonly were "bled to faintness" or lost "1.5 liters [almost 50 ounces] of blood." Therapies that involved the withdrawal of such large amounts of blood were bound to draw some



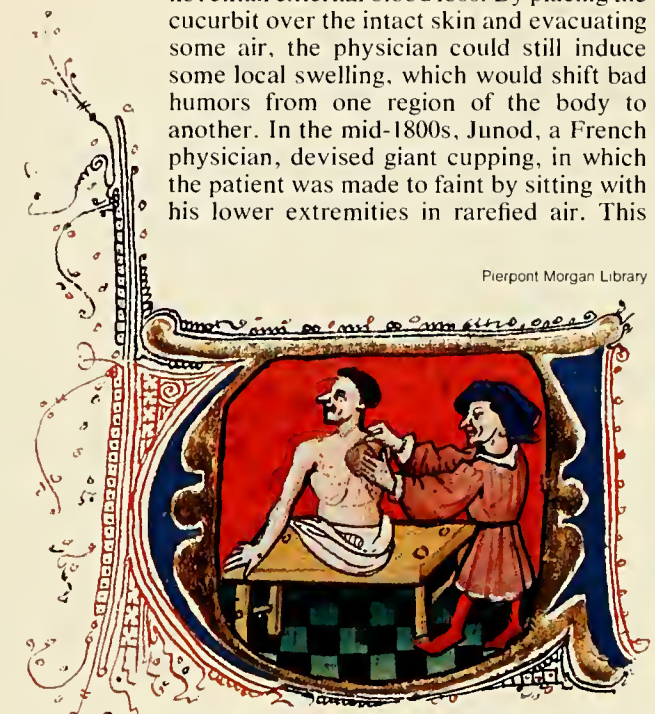
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In a fifteenth-century manuscript, Le régime du corps, *a doctor lets blood; opposite page, leeches cover a man's legs.*

detractors, but they seem to have been surprisingly few. One was William Cobbett, who likened Rush's famous bloodletting cure to "one of those great discoveries which have contributed to the depopulation of the earth." Rush sued for libel; Cobbett was convicted and fined $8,000.

Another form of cupping, dry cupping, did not entail external blood loss. By placing the cucurbit over the intact skin and evacuating some air, the physician could still induce some local swelling, which would shift bad humors from one region of the body to another. In the mid-1800s, Junod, a French physician, devised giant cupping, in which the patient was made to faint by sitting with his lower extremities in rarefied air. This

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In an illuminated letter from the same manuscript, a doctor cups a patient.

position shifted large volumes of blood away from the upper part of the body toward the lower regions. Fainting probably resulted from the decreased flow of blood to the brain.

Various forms of bloodletting have been used until recent times, even in so-called developed countries. How extensive this practice is at present is uncertain, although it is still used by physicians to treat several blood-related disorders, including polycythemia vera, a disease of unknown cause characterized by an enormous increase in the number of red blood cells. Because of the blood's expanded volume and increased viscosity, patients suffering from this disease experience headaches and dizziness. Venesection quickly returns the red-blood-cell mass and blood volume to normal and is often used as a treatment. Venesection is also often effective in treating hemochromatosis, a disease in which the body's stores of iron become excessive, leading to a variety of symptoms, often including heart failure and liver damage. Since most of the body's stores of iron are in the hemoglobin molecules within the red blood cells, periodic removal of blood often returns the patient's iron stores to normal.

Thus, from the time of Hippocrates, Western medicine had a basis—albeit of questionable soundness—and the technology for removing blood as a therapy for most diseases. While bloodletting cannot be traced back before written history, the practice predates Hippocrates by thousands of years. It went on in India and China, and some six thousand years ago, Babylonians were using forms of bloodletting. Their rationale could have been based on observations of sick individuals who vomited, occasionally with blood, or on observations of other causes of blood loss, such as wounds or menstruation. Ancient physicians could have been attempting to simulate and assist natural methods of evacuating the body.

The Greeks may have adopted bloodletting from the Egyptians. According to Mapleson, the Egyptians believed that the water of the Nile, their chief source of potable water, was converted directly into blood once it was drunk. This apparently stemmed from the belief that at the command of the Lord, Moses turned the waters of the Nile into blood. As a result, Egyptians believed they had a plethora of blood and periodically bled themselves to remove some of this excess. Bloodletting was also known to American Indians. In the early 1800s, Lionel Wafer, an English ship's surgeon, described a ritual practiced by Panamanian Indians of the Isthmus of Darien.

> The patient is seated on a stone in a river, and one with a small bow shoots little arrows into the naked body of the patient, up and down, shooting them as fast as he can and not missing any part. But the arrows are guarded, so that they penetrate no farther than we commonly thrust our lancets; and if by chance they hit a vein which is full of wind, and the blood spirts out a little, they will leap and skip about, shewing many antic gestures, by way of rejoicing and triumph.

Wafer then showed these primitive people how phlebotomies were performed in more advanced countries like England. "I bound up her arm with a piece of bark, and with my lancet breathed a vein . . . and I drew off about 12 ounces and bound up her arm, and desired she might rest till the next day; by which means the fever abated and she had not another fit." This demonstration apparently gained Wafer great local fame.

Was bloodletting, one of the most ancient therapeutic procedures, indirectly responsible for the origin of modern experimental medicine? Today, a cornerstone of most

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experimentation is the use of large sample sizes and the science of statistics to analyze and interpret these data. A book published in 1836 entitled *Researches on the Effects of Bloodletting in Some Inflammatory Diseases,* by Pierre Charles Alexandre Louis, was largely responsible for promoting the science of statistics. The older experimental literature was filled with anecdotal evidence or with data composed of a series of isolated observations with little regard for sample size, replicability, and reliability. This type of science makes colorful reading but is problematic in practice.

Suppose an investigator was interested in determining the effects of drug X on the blood pressure of patients suffering from hypertension. If he or she used only a couple of individuals in the study, the results could not be used to generalize about this drug. Suppose drug X reduced the blood pressure in both individuals. Assuming that the administration of placebos led to no change in blood pressure, does this prove the drug 100 percent effective in reducing blood pressure? If ten individuals were tested, the drug might be effective in only six out of ten cases, or 60 percent. When the sample size is increased to one hundred, a fairly respectable sample size in most clinical trials, more meaningful data will be obtained. If drug X reduces blood pressure in sixty-four of the one hundred cases, the investigator can state with reasonable confidence that the drug is effective in reducing blood pressure in approximately two-thirds of cases of hypertension. As the sample size is increased, the investigator can place more faith in the replicability of these data. It is not surprising that in the first experiment, two out of two individuals could have responded favorably simply by chance. If both individuals had failed to respond, this potentially helpful drug might have been discarded before its beneficial effects were discovered.

Yet the concept of using large sample sizes and employing statistics to analyze data was not commonly accepted until fairly recently. Louis was primarily responsible for the advancement of medicine out of the anecdotal and into the modern experimental era. In his book, dedicated to Marshall Hall, he defied the contemporary medical establishment by asserting that bloodletting had little effect on the progress of pneumonia: "The results of my researches on the effects of bloodletting in inflammation, are so little in accordance with the general opinion, that it is not without a degree of hesitation I have decided to publish them." Louis was fairly confident of his assertions because he had employed what he called the "numerical method." He used a large sample size and even divided his experimental population into different age brackets. Louis presented much data that indicated that bloodletting—generally meaning the removal of thirty to forty-five ounces during two or three sessions—sped the course of recovery in patients suffering from pneumonia. Those bled within the first four days remained ill an average of 15½ days and those bled after the fourth day remained ill an average of 18¼ days. However, 44 percent (eighteen out of forty-one) of the patients bled during the first four days died, whereas only 25 percent (nine out of thirty-six) of those that were bled after the fourth day died. Louis believed that these differences, which according to modern analysis turn out to be statistically significant, might be attributable to the differences in ages between those bled early and those bled at later dates. Unfortunately, Louis's study lacked control subjects—patients suffering from pneumonia who were not bled. However, in those days, when there was a general belief in the benefits of bloodletting, an experiment that denied the patient the right to be bled would have been highly unethical.

Summarizing his study, Louis wrote "that bloodletting has a happy effect on the progress of pneumonitis . . . other things being equal, four or five days sooner than those bled at a later date." He also concluded "that pneumonitis is never arrested at once by bloodletting" and "that age exerts great influence on the rapidity of the progress . . . of pneumonitis." While these findings might seem to support advocates of bloodletting, Louis's work was the first experimental demonstration that the practice was not a rapid panacea and that, at best, it had little effect on the speed of recovery. Indeed, Oliver Wendell Holmes—novelist, poet, historian, and physician—considered Louis's findings one of the most important contributions to practical medicine of the nineteenth century. "This was not a reform—it was a revolution," Holmes proclaimed.

Perhaps more important than Louis's specific observations was his defense of the use of large numbers, which allowed the collection of significant data. Louis noted that "it is difficult to collect a sufficient number of cases of any one disease, which shall be identical" but emphasized that this documentation is essential in scientific investigations. Furthermore, he added, the individuals used in a study must "be perfectly equal in age, and mathematically similar in strength, stature and flesh. . . . We are constantly told of the experience of ages in medicine: but how can this experience be embodied, if those who write, instead of saying I have seen so many and so many times, merely say I have often seen, or seldom seen? If there is a means of embodying the experiences of ages, it is the numerical method." While Louis was not the first to use statistics, he certainly exerted a major

influence on the direction of biomedical research.

Despite Louis's book and subsequent articles confirming that bloodletting had little effect on the course of non-blood-related diseases, patients suffering from polycythemia vera, hemochromatosis, and other blood-related disorders could benefit from the periodic loss of blood. In instances of other diseases, rapid loss of substantial amounts of blood could have harmful effects, including increased stress on the heart, potentially leading to cardiovascular shock. The patient would lose proteins such as hemoglobin, albumin, and antibodies. Loss of hemoglobin could result in hypoxia, or decreased oxygen in body tissues, especially during periods of activity.

There are, however, certain non-blood-related disorders in which bloodletting might have had some benefit. For example, removal of blood might have tired a patient or induced somnolence, certainly a cure for delirium or insomnia. Bloodletting also could have served as a placebo for psychosomatic disorders, much as sugar pills do today.

The loss of blood could also have combated many bacterial infections. In order to grow, most bacteria require iron in trace amounts. Blood contains substantial amounts of iron, tied up in hemoglobin and transferrin, a plasma protein with a strong affinity for iron. The body may respond to infection by reducing the level of iron that would be available to pathogenic microorganisms. The host decreases its absorption of iron from the gastrointestinal tract and stores considerable amounts of the iron, which had been bound to transferrin, in the liver. In iron-poor environments, many pathogenic bacteria grow more slowly. The infected organism's fever temperature further reduces bacteria growth. At an elevated temperature, the bacteria appear to be even more sensitive to reduced levels of iron. Over several days, loss of blood in the amounts prescribed in bloodletting would likely result in a greater decline in serum iron levels, further decreasing the growth rate of pathogenic microorganisms that require iron. Hence, in some cases, the potentially harmful effects of loss of substantial amounts of blood might have been counterbalanced by the reduction in iron that would feed invading microorganisms. Some time will elapse before this hypothesis can be tested, for I suspect that in these Proxmirian times, I would have difficulty obtaining a grant to study "The Effect of Bloodletting (Venesection or Cupping) on the Survival Rate of Bacterially Infected Mammals." □

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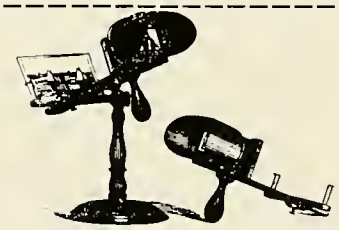
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How the West Was Won

by Gerald Carson

Barbed wire made it possible to occupy the treeless western prairie

It probably happened a thousand times. A "mover" from one of the old eastern states halted his wagon, with old "crumpled horn" tied on behind, somewhere in central Indiana where the timber thinned out. He climbed a bur oak tree for a look ahead toward the Illinois country and gazed to the west with a rush of emotions—astonishment, excitement, a lift of the spirits, a sense of awe sometimes mingled with anxiety and fear. For the settler, this man from the forested east, saw a level, almost treeless land of undulating prairie grass tall as a horse and rider, reaching to the far horizon: a fertile, virgin land filled with promise—and threat. The phenomenon was without precedent in the pioneer's life or the lives of his ancestors.

Some thought the scene monotonous; others found it strange but beautiful. The analogy of a great, green sea was often invoked by travelers of the period from 1830 to 1860. The wind stroking and swinging the tall bluestem grass of the meadowland brought to mind waves; the occasional, isolated groves, or "bushes," seen shimmering in the distance suggested sailing ships moving under full canvas.

This was the middle border, the tallgrass prairie, the future Corn Belt. It covered 70 percent of Illinois and parts of Michigan, ran west to Minnesota, and curved south into large portions of Missouri and Kentucky; it was well watered and incredibly rich in its soil, but timber for housing and fences ranged from skimpy to nonexistent. And, farther west, beginning approximately at the 98th meridian and stretching to about the 120th meridian, lay the shortgrass plains with their dense sod of buffalo grass and blue grama: a treeless country, a new environment, deficient in rainfall, with a distinctive plant and animal life, controlled by the range cattle industry.

Farmers had to have fences. Until the settlers reached the prairies of the Middle West, fencing materials of one sort or another had usually been ready at hand, not the product of industry, but simply a byproduct of clearing the land for agriculture. Stone hauled by oxen from the fields formed the rock walls of New England and eastern New York. Laying up a good dry wall took time, labor, skill. It was exhausting work and required, according to folklore, a gallon of rum for every rod of fence. Timber was also abundant—at first—yielding logs for houses and barns and sometimes for split rails to top the rock walls.

Farther south the earliest fences were made of brush moved to the edge of a clearing, a frail barrier followed later by stump fences, post-and-rail fences, and laid-up rail fences, the ends of the rails resting across each other in zigzag patterns, sometimes held together at the cor-



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There wasn't anything special going on that day

(except Mrs. Emmons taking a picture of Moses Mitchell at his mill)

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There is also another way to make great photographs—Netta's way, where there is no color to lean on and no dyes to fade a bit as the generations pass. That is, black-and-white photography! We still make fine products like Kodak Panatomic-X film and the faster Kodak Plus-X and Tri-X films for little girls who just can't hold as still in shady places as Hazel True did.

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*_Chansonetta_, by M. B. Péladeau, available at $8.95 from _Maine Antique Digest_, Box 358, Waldoboro, Maine 04572 and from bookstores.

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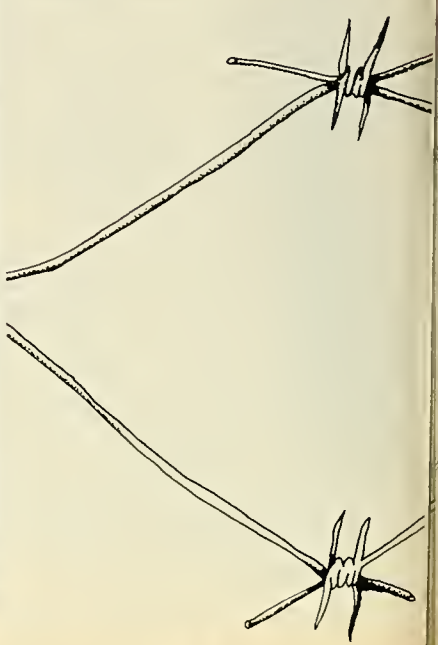
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ners by slanting posts and variously known as worm, snake, or Virginia fence.

The American diaspora that debouched from the eastern woodlands onto the prairie has provided a dramatic and traumatic instance of the struggle of man versus environment. It has engaged the attention of writers on social history, sociology, agriculture, and anthropology. They have noted the cultural shock; the inadequacy of available tools in the new setting; the attitudes, laws, and customs that had to be modified to meet the new situation; the wrenching adjustments; the improvisation that settlers of eastern origin had to make. In the process of occupying the land, fencing became a major obstacle to settlement. Indeed, during the Civil War, an Iowa journalist declared, "The subject of fences is as important as that of ironclads."

The fencing problem was critical for the prairie farmer but not entirely new. A growing scarcity of timber, the rising cost of labor for splitting rails, and fence maintenance became topics of earnest discussion and concern in the older states between the 1830s and 1850s. As early as the 1790s, George Washington was expressing his dissatisfaction with timber fences and had begun to experiment with hedges and ditches. An anecdote is told of John C. Calhoun that he complained vigorously about the census of 1850 because it left out the most important product of domestic industry.

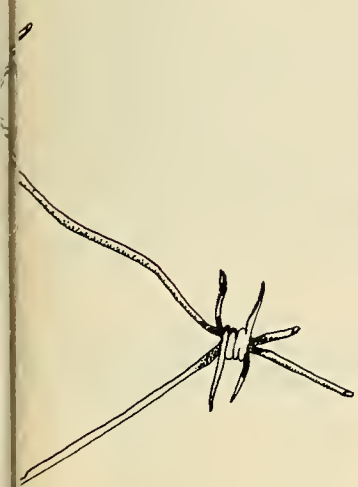


"What is that?" a friend inquired anxiously.

"Fences, fences," Calhoun replied. "They cost more and are of more importance to us as an agricultural people than any other department of domestic industry."

On the plains of the Middle West every idea that held the least promise was tried: mud fences with a cap-and-stake fence on top of the balk; ditch-and-bank fences, which stock quickly trampled into uselessness. Hedges, or "life fences," enjoyed a vogue. These were made of Cherokee rose, hawthorn, honey locust, red cedar, cottonwood, white willow, and bois d'arc, or Osage orange, which grows rapidly and has long, sharp thorns. The popularity of this last species, from about 1840 through 1870, was called various things by skeptics—a "mania," a "prairie humbug," or "hedge fever." Osage orange is a southern plant; its hardiness in northern climates was questionable. Furthermore, constant trimming was needed or the hedge became trees, easily penetrated by cattle.

The great hopes held out by advocates of the hedge fence were dashed as the defects of the Osage orange became apparent. Although the initial cost of a hedge fence was low, it required from three to five years to get a good growth, and prairie fires could always destroy the small plants. Sheep and small animals ate the bark and leaves, and once set, a hedge fence could not be



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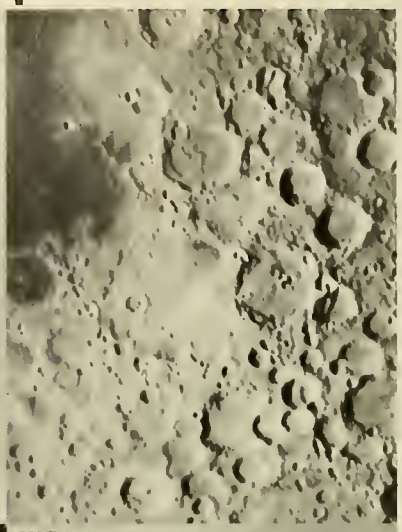
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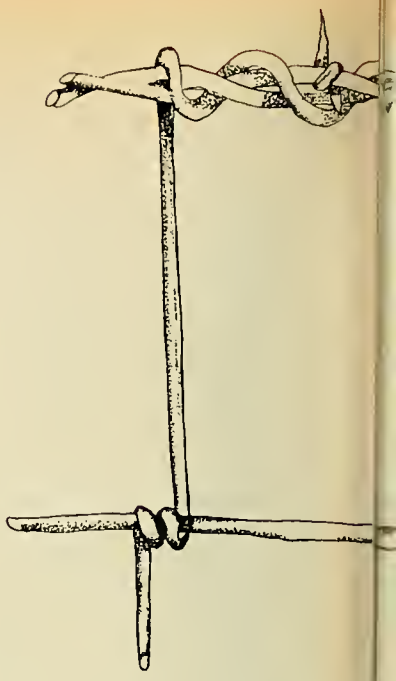
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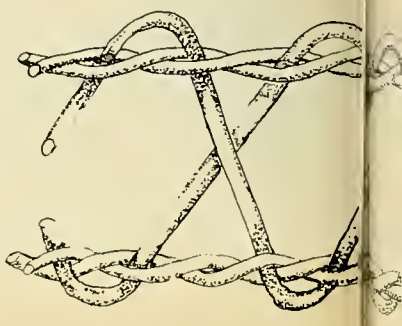
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moved. Furthermore, it sheltered weeds, vermin, and snow; used up space and nutrients; and cast an unwanted shade.

Board fences were common in the upper Mississippi Valley after the railroads had tapped the pineries of Wisconsin and Minnesota, but there were limits set by distance, freight costs, and diminishing supply. Many pioneers who could reach timber without too long a trip preferred to "haul and maul," that is, make rails. This was possible in limited areas where the bluffs and flood plains of rivers and streams provided the raw material.

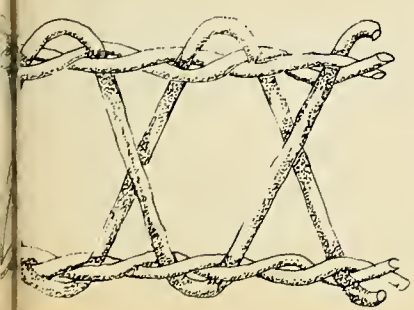
But wooden rails also had their disadvantages. They required much labor and were subject to fire, rot, and theft. The Virginia zigzag was an easy mark for a type of vagrant





hog called, in Illinois, the "prairie racer," which would root, burrow, and squirm until it had got its sharp, pikelike nose under the bottom rails so it could start heaving the fence down.

According to an estimate made by the *American Agriculturist* in the pre-barbed-wire days, maintaining rail fencing absorbed one-twelfth of the total annual labor on a farm. Necessary, yes, but nonproductive work. For the country as a whole, in the 1860s the cost of fencing for crop agriculture ran about twice the value of the land. This gives some idea of the pressure behind the search for some big innovation, some solution that had not been thought of before, that would result in fencing capable of controlling unruly animals, simple in



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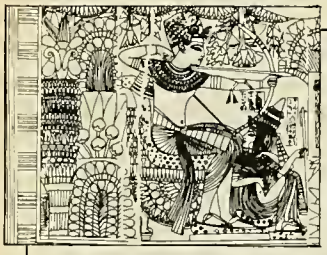
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structure, cheap in cost, and practical for the ordinary farmer to erect.

The search turned to a product of industry, smooth wire. Made of ungalvanized iron, the wire had to be painted to avoid rust, was not uniform in tensile strength, snapped in cold weather, and sagged in hot. It held no terrors for cattle. Livestock learned to loosen the posts and to lean on the wire until it gave way. Allan G. Bogue, a specialist in the economic history of the West, has expressed what happened with humorous realism: "Cattle and horses viewed the wire fences . . . with friendly tolerance; after they had scratched out their winter coats upon them, they found easy passage. Pigs scorned them utterly."

The urgent, nationwide search for a better form of fencing continued. Farmers, mechanics, and tinkerers began to experiment with ways to attach sharp prongs, thorns, or barbs to the wire. Despite technical deficiencies in drawing, annealing, and tempering wire, it did have some of the desired qualities. It took up no room, extracted nothing from the soil, cast no shade, was immune to wind



Barry Donahue

and snowdrifts, was durable and inexpensive.

No one person invented barbed wire—many individuals contributed, usually gropingly, to the gradual unfolding of the concept. A number of eastern men took out patents in the 1860s, but their models proved to be impractical and, in any event, could not be machine manufactured. The wire that met the specifications was the work of practical men of the West who lived close to the problem, especially three men—Joseph F. Glidden, Jacob Haish, and Isaac L. Ellwood—who all lived in or near De Kalb, Illinois, a village on the edge of the prairie country. According to Ellwood, the three visited the De Kalb county fair in 1873 and saw there an exhibit of a strip of wood about sixteen feet long with the sharp points of brads sticking out of it. The notion was to hang it as a visible repellent on a smooth wire fence.

"All three of us," Ellwood said, "stood looking at this invention . . . and I think that each one of us at that hour conceived the idea that barbs could be placed on wire in some way instead of being driven

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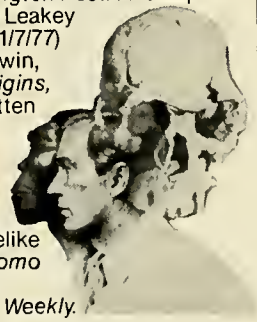
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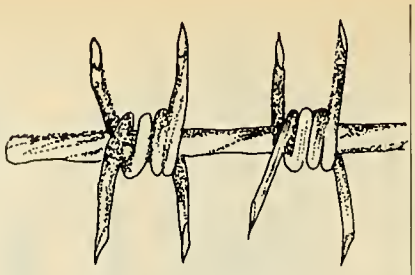


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into the strip of wood." Haish, a local lumber dealer and contractor, developed an S barb in his carpenter shop. Glidden, who lived on his farm west of town, made his first barbs in his kitchen, using an old-fashioned wall coffee mill that had been adapted by a local blacksmith for the work of twisting the prongs. The handle was turned, according to a generally accepted story, by Glidden's wife, Lucinda. At first, Glidden put barbs on a single wire but had difficulty keeping them properly spaced. One day, having accidentally tangled wire only part of which was barbed, he got the idea of wrapping the plain wire around the wire already fitted with the sharp points so as to snub them securely in place. The twisting was done by a crank taken from an old grindstone and mounted on a trestle. As recollected by one of Glidden's associates, this crank, too, was turned by Lucinda.

Both Glidden and Haish were prompt, aggressive, and successful in securing patents. Both twisted two strands of wire, but their products differed in the way the barbs were attached. Production and sales expanded rapidly, but patent infringement was widespread in Illinois and Iowa, and the business was so easy to enter that the manufacture of "moonshine" barbed wire became practically a regional cottage (or barn) industry. Glidden's wire, appropriately named Winner, is regarded as the most important step taken by anyone in perfecting barbed wire. His first conception was complete, needed no further refining, and had the patentable characteristics that enabled it to fend off years of spectacular attacks in the courts.

Ellwood, a De Kalb hardware merchant, saw the Glidden wire in use, acknowledged that it was better than his own scheme, and opened negotiations to become Glidden's partner. This accom-

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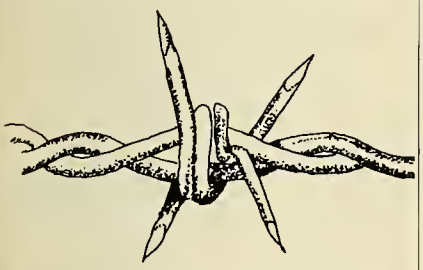
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plished, Ellwood later bought Glidden out, and by a complicated series of consolidations, their interests ended up in the United States Steel Corporation.

Haish preferred to go it alone. The Glidden and Haish products remained in conflict in the courts and in competition in the marketplace for many years. Haish, who died only a few days before his hundredth birthday, had long before placed over the doorway of his home in De Kalb a sign reading "Jacob Haish, Inventor of Barbed Wire."

With "bobbed wire" available in almost unlimited quantities—and enhanced in quality with the introduction of the Bessemer steel wire process—old problems, such as herd laws, became aggravated. Under English common law the obligation to erect a legal fence was placed upon the owner of livestock, not the cultivator of crops. But in British America the law was reversed. America was a land of immense forests and pastures open to



all as public commons for grazing, while the limited amounts of land under cultivation for subsistence farming could be enclosed.

This new situation was recognized by colonial statutes and carried on under state law, that is, the farmer had to enclose his crops to sustain claims of trespassing and damage. The custom of allowing animals to run at large continued for a long time. As late as the 1850s, hogs and cows were the cause of accidents in New York's City Hall Park. Farm animals ranged freely in Washington, and according to a standing joke, every third person one met in Cincinnati was a hog.

The fence-law problem followed the settlement line as it moved west. In Illinois, Iowa, and eastern Kansas and Nebraska the battle was fought bitterly, usually on the township or county level, the issue depending on the dominant charac-



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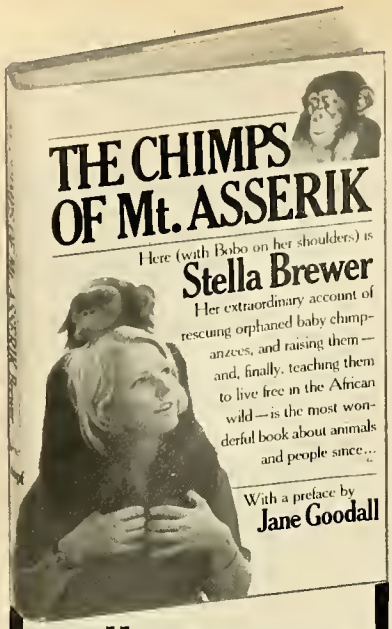


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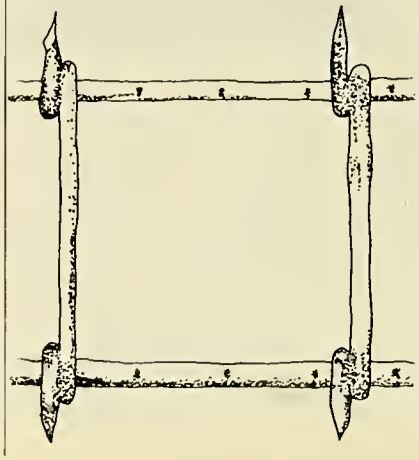
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ter of the local agriculture. The heat generated by the herd-law dispute is suggested in the testimony of a Nebraska farmer who rose in the legislature, his hands rammed down hard in his pockets, and said in a shaking voice: "Mr. Stone [English jurist Sir William Blackstone] did not know anything about Herd Law, never was in Nebraska, and besides he weren't no farmer."

Slowly, public sentiment turned to favor stock confinement, and state legislatures responded by passing fencing laws that required owners of herd animals to put up fences and defined the legal basis for trespass, distraint, sale, and damages. In the end the cheap barbed wire made possible a more diversified agriculture on the tallgrass prairies. Thus technology, plus legal remedies, set the future of the Corn Belt, drawing to the new West the crop farmer, the land speculator, the doctor, the town-site promoter, and the briefless lawyer with his library—*Blackstone's Commentaries* and *Chitty on Pleading*—in his carpetbag. All were bent on prospering in the new country whose development barbed wire had, to an important degree, made possible.

West of the 98th meridian, which cuts down through eastern South Dakota, central Nebraska, Kansas, Oklahoma, and Texas, barbed wire played a prominent part in the conflict between the cattlemen and homesteaders. In this contest the wire was decisively on the side of the nester and against the economic order built around the longhorn steer, the roundup, and free grass. From the very beginning of large-scale manufacture of barbed wire,



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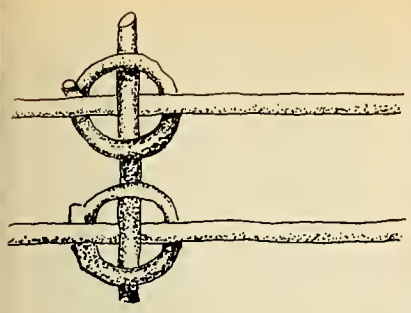
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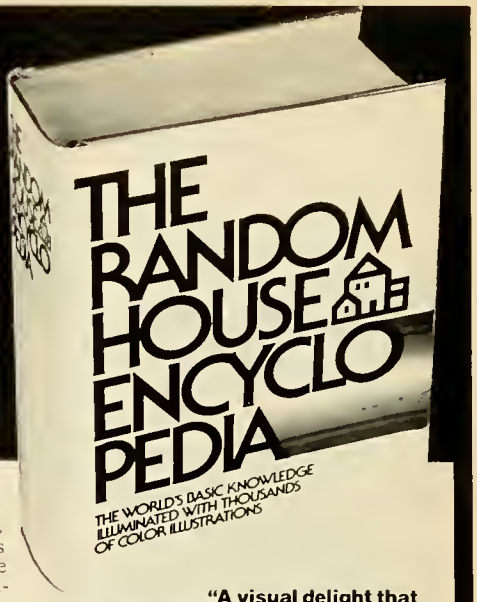


the Great Plains was recognized as the primary market for the wire. Isaac Ellwood, having gained full control of the Glidden patents, sent representatives, among them John W. Gates, a superb salesman, to San Antonio, with samples of barbed wire. Skeptical cattlemen thought the new fencing was flimsy, cruel, likely to cut stock, in sum, a "Yankee fake." Gates was a flamboyant figure who added much color to the barbed wire business. At San Antonio, while he was sitting in a Mexican chili parlor, Gates watched the medicine show of "Doc" Lighthall, a skillful peddler of miraculous remedies.

"We'll do like 'Doc' Lighthall," Gates exclaimed to a friend. He got permission to put on a free show in the main plaza next to the cathedral. There he set up a corral with post and wire and invited the ranchmen to bring on their most vicious beef brutes. He praised his merchandise in authentic carnival style as "the finest fencing in the world, light as air, stronger than whiskey, cheaper than dirt, all steel, and miles long. The cattle ain't born that can get through it."

Twenty-five wild steers were driven into the enclosure. There was much sound and fury as the longhorns charged against the fence. The wire held. The beasts tried again but could not breach it. After repeated attempts, they gave up, milling about restlessly but avoiding contact with the sharp prongs. Cowmen and farmers found that seeing is believing. It was a historic moment and, as events turned out, made Gates's fortune. Shortly, another profitable market opened up—the railroads, which required thousands of miles of multistrand barbed wire to protect their rights of way. Soon wire agents were crisscrossing the High Plains and sending back carloads and even

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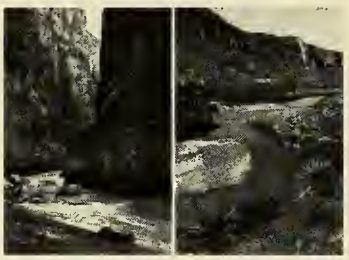
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trainloads of the shiny spools of wire.

Gates appraised the situation and finding there was more money to be made in manufacturing than in distribution, he turned his formidable promotional talents to putting together a huge complex, the American Steel and Wire Company, later a component of the United States Steel Corporation. His shrewdness, persuasiveness, and audacity in risk taking earned for him the nickname Bet-You-a-Million Gates, although he denied ever having said it. Since this is an account of the environmental, social, and economic consequences of the introduction of barbed wire, we bid adieu to Gates at this point, leaving him to the enjoyment of his fortune —his diamond-studded shirt front, his cuff links and suspender buckles with similar adornments, his Paris apartment, and his Corots and Meissoniers.

Pulp magazines, paperback Westerns, the movies, and television specials have thoroughly exploited the dramatic possibilities inherent in the range wars between cattlemen and sheepherders. Yet in the opinion of a responsible historian of the West, Joe B. Frantz, "A greater menace than sheep was the introduction of barbed wire . . . the barbed wire came to enclose range, waterhole, and trail . . . barbed wire was savage, unrefined, and hard—and it made the Great Plains finally fit for settlement . . . ." And a western poet sang sadly of "the prairie cleft by skirmish lines of fence," adding in anger:

> They say that heaven is a free range land,
> Goodbye, goodbye, O fare you well,
> But it's barbed wire for the devil's hat band;
> And barbed wire blankets down in hell.

In the spacious days of the open range the kings of the free grass country owned the cattle but not the land. With the appearance of the farmers and small stockmen who owned and fenced their holdings, including scarce water resources, the ranchers out of necessity began to acquire land and to fence it. This they often did somewhat carelessly, enclosing stream banks and water holes they did not own, large chunks of the public domain, and even cutting off established public roads and access to the home places of landowners who held deeds to their property. If the "little man" removed an illegal fence, threatening notices were posted for his attention. One ran, "The son of a bitch who opens the fence had better look out for his scalp"; and a letter writer threatened that if the nester violated the signs on the fence, a cowboy "just points his Henry rifle in the direction where it will do the most good, and if someone is killed it is charged up to the Indians or the highwayman." The granger, for his part, plowed up his quarter section and turned a furrow around the claim. When cattle strayed from the rangeland onto his cropland, he shot them, thereby protecting his homestead and also furnishing his family with

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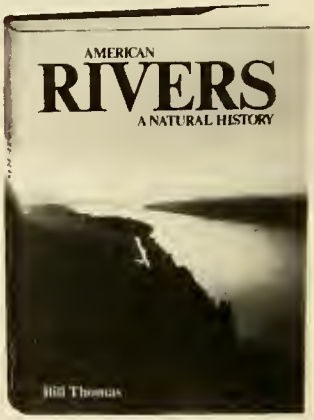
The inconveniences that the new barriers caused the Indians, the buffalo herds, the "brand burners," and the cattle thieves were universally welcomed. But on the level of economic competition, the conflict between old and new ways of life led to terrorist tactics, including fence cutting, which in 1883–84 grew into what was called "the barbed wire war," with both sides, the big-pasture men and the farmers, wielding the wire nippers. The war started in Texas, Wyoming, and New Mexico, then spread to Nebraska, Colorado, and Montana. Honest men, wranglers, thieves, and outlaws formed an unlikely alliance but shared a common determination, each for his own reasons, to destroy the new fencing and reopen free passage to grass and water. Well-organized groups accomplished their ends under cover of darkness and drawn revolvers. Civil commotion followed. Stock was poisoned, grass fires set. There was dynamiting of homes, mayhem and murder.

Grand juries would not indict. Petit juries would not convict. In Texas the war waged by the nightriders was ended by the Rangers and the action of a special session of the state legislature that prescribed rules for reasonable fencing and made fence cutting a felony. Gradually, public opinion lined up in support of the law. In other states, also, new fencing laws were enacted and came to be accepted.

The ultimate effect of the armored wire was to turn the range into stock farms, reduce the number and status of the cowhands, make possible improved herds because of selective breeding, and open the way to grain farming, that is, a mixed form of agriculture. Social changes were equally striking. As the trail hand and the chuck wagon disappeared, a new civilization—built around family life, the church, and the school—took over the land, and public roads connected the rural population with nearby market towns.

Offbeat uses of the wire included emergency repairs to farm machinery and as a substitute for a rope or chain in pulling stalled Model Ts out of mudholes, with a fence rail, if available, assisting as a pry. Another use, undreamed of by the inventors of barbed wire, appeared

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when small, local telephone companies, often owned by their subscribers, linked farms together by hooking lines on to pasture fences and letting the barbed wire carry the talk traffic, subject, of course, to interruptions by bolts of lightning, the opening of a field gate, or a mishap involving an angry bull. The first rural telephone line in Kansas was strung on a barbed wire fence in Riley County in the 1880s, and one such primitive transmission line was reported in active service as late as 1952. All families had their own ring on the party line. When any number was rung up, all the neighbors' receivers were taken down with an audible click, so that they, too, could share the news and gossip and so break the monotony and loneliness of farm life.

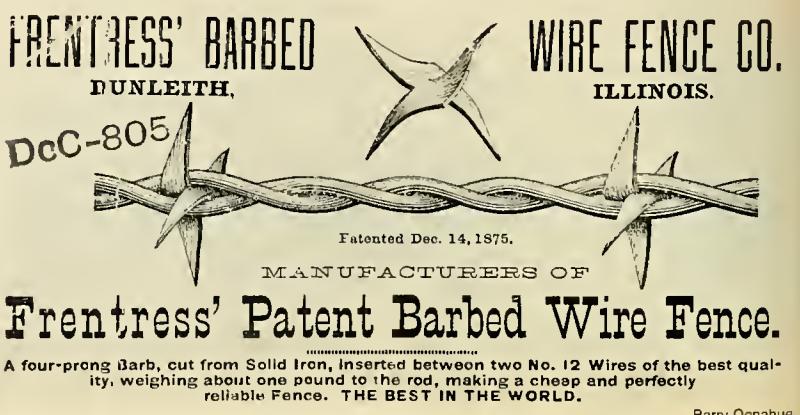
Barbed-wire technology shows up in darker colors in the present century because of the part played by the wire in war and politics—such as the dreadful entanglements of World War I trench warfare; the concentration camps of World War II; the appearance in Vietnam of "apron" wire fastened on X-shaped steel stakes. A variation was concertina wire, so called because the free-standing, rolling whorls could be pulled out like the bellows of an accordian and installed around the perimeter of a defensive position or snapped back into a roll and moved to a new location. And barbed wire still routinely protects the chancelleries and palaces of today's dictators.

Many history buffs find that they can best get the feel of the past from the artifacts left behind, such as buttons, bottles, spurs, furniture, manuscripts, stamps, china, glass—and barbed wire. An estimated 10,000 to 50,000 Americans are engaged in assembling personal collections from among the approximately 600 kinds of wire that have appeared in the last hundred years. To qualify as collectable and worthy of being mounted on a showboard, each specimen must be eighteen inches long.

Wire enthusiasts have strong romantic and nostalgic feelings about the stuff. There are a dozen state barbed wire associations, an international group of collectors, a *Who's Who in Barbed Wire*, a Barbed Wire Hall of Fame, and numerous society bulletins, two flourishing newspapers, and many handbooks for the identification and classification of barbed wire. Metal detectors and even helicopters have been pressed into service: the first for scanning old refuse heaps and farm dumps; the second for skimming over ancient fence rows that might contain fragments of some rarity—a length of #141 Spur Rowell or of Glidden's Winner or of 1882 George Elsey Ribbon.

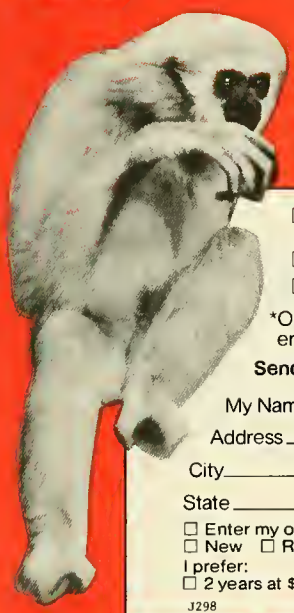
An annual Barbed Wire Swap and Sell Session is held each year in the little town of La Crosse, Kansas, which calls itself the Barbed Wire Capital of the World. Splicing contests for the world championship are a feature of these yearly conventions, with a Junior Division for the youngsters, and contests for women, called the "Powder Puff Division." After a parade and a Saturday night banquet, contented collectors drive home with bits of rusting metal worth, in the market their enthusiasm has created, up to $150. As one "barbarian" explains the fascination of the search, "It smacks of the Old West."

Gerald Carson, author and social historian, is a frequent contributor to Natural History.



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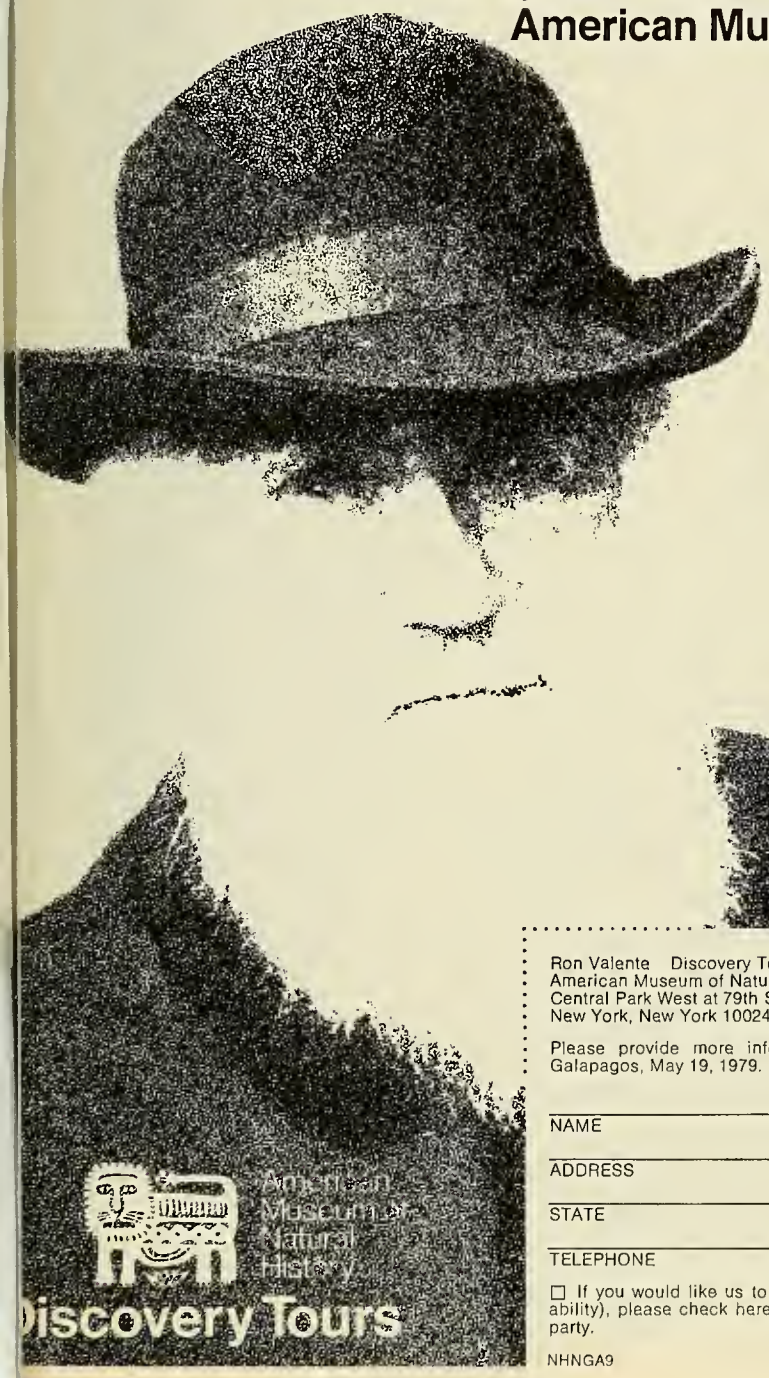
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Celestial Events

by Thomas D. Nicholson

Sun and Moon The sun in November is well south of the equatorial plane, in the constellation Libra for most of the month. It will move into Scorpius about the 23rd and into Ophiuchus before month's end. It doesn't reach the winter solstice for another three weeks but is within a few degrees of its most southerly position by the end of November, when daylight is only 15 minutes longer than at the solstice.

We have an evening moon for the first half of November and December, and a morning moon from midmonth on. In November, first-quarter moon is on the 7th, full moon on the 15th, last-quarter on the 22nd, and new moon on the 30th. The next first-quarter moon is on December 6, full moon on the 14th. Perigee occurs on November 5 and December 2, apogee on November 20.

Stars and Planets There are no planets on the November evening Star Map because none are above the horizon in the early night hours. Mercury, Venus (until November 7), and Mars are evening stars, but are too low at sundown and set too early to be seen. Jupiter comes up later at night and by midnight will be very bright and high in the east, midway between the bright twin stars of Gemini (Pollux and Castor) and Regulus (in Leo). And about midnight, Saturn rises in Leo, behind (to the left and below) Regulus. Both Jupiter and Saturn are morning stars and will be very prominent in the dawn sky. Jupiter, the brighter of the two, will be high in the south; Saturn will be to the left, past Regulus (quite similar to Saturn in brightness). Late in November and early December, Venus will be very prominent as a morning star, becoming bright and easily seen above the southeastern horizon at about dawn.

November 4: The shower of meteors radiating from Taurus reaches maximum. You may see up to 15 meteors per hour from this weak, broad, and dispersed stream, but most are dim.

November 5: Mercury and Mars are in conjunction.

November 7: Venus is at inferior conjunction (between the earth and the sun) and enters the morning sky.

November 15–16: An occultation of the bright star Aldebaran by the moon will be generally visible throughout North America. The star will disappear behind the moon's edge some time between 10:00 and 11:00 P.M., EST, and emerge within an hour. Times and duration vary with location, and adjustment should be made for different time zones. Aldebaran is quite bright, but binoculars will enhance visibility when the star is very close to the nearby full moon.

November 17: The Leonid meteor shower is at maximum this morning. You may see up to 15 shower meteors per hour, swift and often very bright.

November 20–21: Jupiter rises and remains near the moon.

November 23–24: Saturn, rising about midnight, is near the moon; Jupiter is to the west (right) of both.

November 25–26: Three planets change the direction of their movement through the stars. Mercury and Jupiter begin their westerly (retrograde) motion; Venus ends its retrograde swing and resumes direct (easterly) motion.

December 5: Mercury enters the morning sky.

December 13: Another occultation of Aldebaran may be seen along the Pacific Coast at about moonset early this morning.

December 14: Venus is at greatest brilliancy as a morning star.

★Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:10 P.M. on November 1; 10:15 P.M. on November 15; 9:20 P.M. on November 30; and 8:20 P.M. on December 15; but it can be used for an hour before and after those times.




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The Allende Meteorite

Studies of the composition of this body are forcing planetary scientists to revise their theories of the solar system's formation

During the past nine years extensive studies of remarkable material from a single meteorite have been carried out in many laboratories throughout the world. These investigations show that various mineral assemblages within this meteorite are well-preserved relics of primitive material dating back to the earliest history of the solar system. There is even a chance that fossil presolar grains have been found within this material. These discoveries have had a major impact on our thinking regarding the formation of the solar system. A case could be made for the claim that even more will be learned regarding the early solar system from the study of this meteorite than from the extremely rewarding studies of rocks returned from the moon by the U.S. Apollo and USSR Luna programs.

The story of the meteorite began in the valley of el Rio del Valle de Allende in the central region of the state of Chihuahua, Mexico, about 185 miles south of the Texas border. In the early morning hours of February 8, 1969, a meteor brighter than the full moon was seen over an area of almost a million square miles. Locally, this was accompanied by powerful sonic booms. The object producing these phenomena fragmented in the atmosphere and thousands of stone meteorites fell to earth, covering an area of more than a hundred square miles.

For weeks following the event, scientists from numerous institutions in Mexico, the United States, and Canada converged on the area and, with the help of local residents, recovered hundreds of pounds of material for scientific investigations and museum collections. When material found by private and commercial collectors is added, scientists estimate that more than two tons of meteorite fragments have been removed from the region, and undoubtedly much still remains to be found. Thus the Allende meteorite represented the largest known stone meteorite fall up until that time, possibly exceeded only by the fall of the approximately three-ton Kirin meteorite in China in 1976.

We have known for almost two decades that the minerals that make up almost all meteorites are 4.5 billion years old and date back to the general period of time in which the sun and the planets were formed. We have also known that meteorite fragments could not have had their present small dimensions of about three feet or less for more than the last few million years. This is clearly shown by the fact that meteorites contain only a limited quantity of the inert gas isotopes produced by nuclear bombardment by energetic galactic cosmic rays. Measurement of these nuclear reaction products permits calculation of the "cosmic ray exposure age" of the meteorite. Stone meteorites typically have exposure ages of less than 20 million years. The longest exposure interval found is about 100 million years,

the shortest is only 19,000 years. Prior to those times, relatively recent compared with the age of the solar system, the meteorites must have been in the interior of a larger body, one at least large enough to shield the meteorite from the effects of galactic cosmic rays.

The precise identity of these larger "parent bodies" is not well understood at present. Most workers believe they are asteroidal bodies, either the minor planets that populate the region between Mars and Jupiter or the nearer rocky planetoids known as Apollo and Amor objects, which approach the orbit of the earth and moon and are our nearest neighbors in interplanetary space. Another possibility is that at least some meteorites are residues of comets that have lost their volatile ices by repeated approaches to the sun. All of these diminutive solar system objects are sufficiently small to have escaped the effects of the thermal and atmospheric geologic processes that have erased the primordial record from the rocks of larger and more active planets such as the earth, Mars, and the moon.

For these reasons we expected that, like other meteorites, studies of the Allende meteorite would provide data relevant to the formation of the solar system. The actual results, however, soon far exceeded these expectations.

Simple macroscopic examination of the Allende specimens showed that this was not a typical stone meteorite. It consists of a fine-grained, rather opaque matrix in which are embedded numerous inclusions of various kinds. Many

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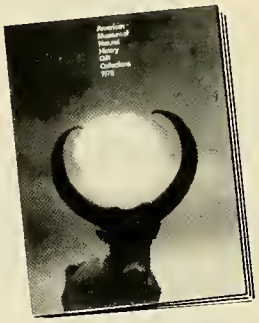
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closely resemble the tiny spherical globules called chondrules that are found in the most abundant type of stone meteorite—the chondrites. But far more significant were some unusually large (up to about one inch in diameter), whitish globules and chemically related, large amoeba-shaped, fine-grained aggregates of foreign material. Studies of these inclusions carried out in 1969 at Argonne National Laboratory and at the Smithsonian Astrophysical Observatory revealed a chemical composition very different from the solar system composition generally found in chondritic meteorites, in main-sequence stars, and in the sun.

This average solar system composition can be simply described. First, there are those elements abundant in stars but greatly depleted in meteorites as a consequence of the volatility of their usual chemical form, namely, hydrogen, helium, carbon, nitrogen, and oxygen. Next are the most abundant elements that form nonvolatile mineral compounds—magnesium, iron (alloyed iron and nickel), and silicon. The last three elements, together with the oxygen with which they are combined, constitute 80 to 90 percent of almost all stone meteorites, including bulk specimens of Allende. Finally, there is another group of three elements less abundant by a factor of about ten—calcium, aluminum, and sodium. With the exception of the rather volatile element sulfur, all other elements are less abundant by an additional factor of about ten or more.

In the large and/or irregular Allende inclusions, however, the usual abundance of calcium and aluminum relative to iron and magnesium is reversed. The generally minor elements are the most abundant. (As would be expected, the mineral assemblages in the inclusions are also highly unusual. The most abundant minerals are such meteoritic rarities as melilite, perovskite, spinel, grossular garnet, hibonite, and pyroxene rich in aluminum and titanium, all composed primarily of calcium, aluminum, silicon, and oxygen.)

Mineralogical investigators quickly recognized that these rare substances were the very minerals that had been theoretically calculated to be the earliest condensates to form during the cooling of a primitive high-temperature (about 2,000°K) nebula of average solar composition. Taken with other evidence for the primitive nature of the Allende meteorite, this led to a widely held opinion that these small fragments are actual samples of the first solid material to condense from the primitive nebula of dust and gas from which the sun and planets were formed.

Investigators soon also recognized that the Allende meteorite was not a freak of some kind but was simply a larger and more available representative of a minor, but fairly common, type of meteorite. Eight other examples are known and all of them contain high-temperature inclusions, that is, minerals predicted to form at high temperatures. In fact, these meteorites had already been classified as a subtype of carbonaceous chondrites, and their high-temperature inclusions had been identified as early as 1961. Widespread recognition of the significance of these inclusions, however, did not come about until after the more generally known work with Allende.

The interpretation of these inclusions as early condensates now appears likely to be an oversimplification. There is good, if not altogether compelling, evidence that the minerals in these high-temperature inclusions condensed first as liquids and then as solids, rather than being direct condensates from a gaseous phase. In addition, some anomalous low-temperature minerals such as sodalite were also found in these inclusions. Furthermore, the reality of a high-temperature solar nebula of the sort envisioned by meteorite investigators has been seriously questioned by some theoretical astrophysicists. It is quite possible that the chemical identification of a high-temperature component in the early solar system will survive questioning, but the mineralogical identification of the inclusions with direct condensation from the solar nebula may have to be abandoned. Like many of the other remarkable properties of this meteorite, the formation of the inclusions is poorly understood at present.

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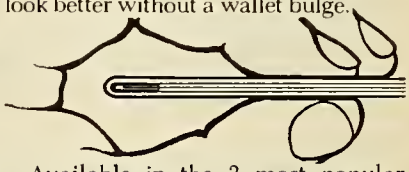
the isotopic composition of its constituent elements. At first, these measurements seemed interesting and readily understandable. The intimate association of high-temperature inclusions with more usual low-temperature material in the matrix was evidence that the meteorite was an unmetamorphosed and hence primitive object. Therefore, investigators were not surprised when radioactive-dating methods showed the Allende meteorite to be 4.5 billion years old—essentially the age of the solar system itself. Several laboratories reported that the meteorite contained strontium of primitive isotopic composition, as well as other now extinct, relatively short-lived radioisotopes assumed to have existed in the early solar system. The discovery of such extinct radioisotopes in other meteorites was made as long ago as 1960 and formed the apparently firm basis for a galactic chronology. According to this timetable the last addition to the solar system of isotopes synthesized in the interior of stars took place about 100 million years before the formation of the meteorites, the planets, and the sun.

All findings seemed to be compatible until 1973 when Robert Clayton of the University of Chicago discovered variations in the isotopic composition of oxygen in Allende's calcium-rich inclusions. The ratio of two oxygen isotopes—^{18}O and ^{16}O—to each other had been measured in many meteorites and terrestrial rocks in order to determine the temperatures at which the material had formed by means of the small but calculable differences in the chemical properties of these two isotopes. It was not customary to measure the amount of a third stable isotope of oxygen—^{17}O—since the chemical variation in the ratio of ^{17}O to ^{16}O was typically one-half the variation in the ratio of ^{16}O to ^{18}O. Hence no new information appeared to be obtainable by this procedure. Nevertheless, Clayton did measure both ratios in the Allende inclusions with the surprising result that the variation in the ratio of ^{17}O to ^{16}O was the same as that of ^{18}O to ^{16}O, instead of being half as large.

This finding implied that the phenomenon was a nuclear rather than a chemical effect. Evidently, in addition to the usual chemically in-

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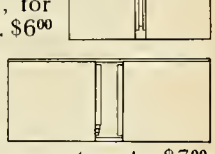
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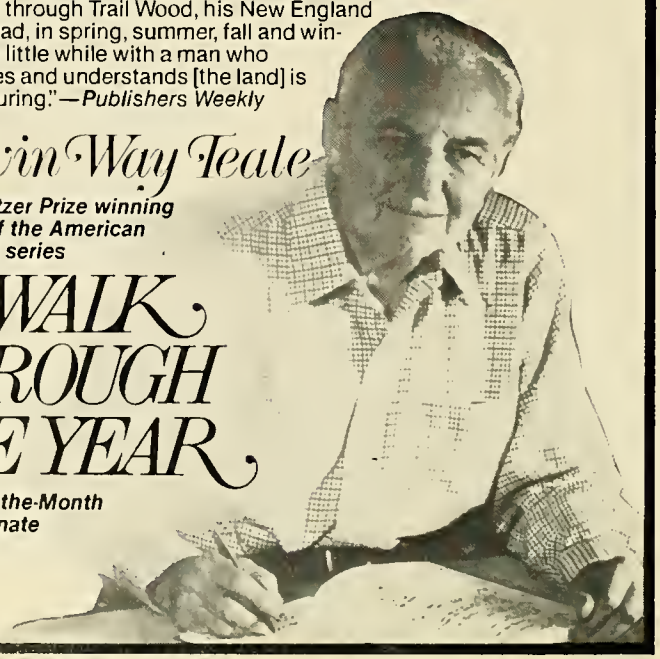
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duced variations in the oxygen isotope ratios, a component of pure ^{16}O was present in amounts that varied from one microscopic mineral grain of the inclusion to another. Unexplained nuclear variations in the isotopic abundance of such rare elements as neon and xenon were known to occur in meteorites. For such extremely rare elements, very small quantities of isotopically distinct material are sufficient to produce measurable isotopic differences. But oxygen atoms make up about 60 percent of the atoms in the Allende inclusion. The approximately 4 percent ^{16}O enrichment found by Clayton was thus a gross effect, which would be easily visible to the naked eye if the added ^{16}O were, for example, of a different color from the "normal" oxygen in the minerals of the inclusion.

The determination of this oxygen isotopic anomaly was followed in 1975 by isotopic anomalies in magnesium, again a major chemical constituent of the Allende material. This discovery, reported by workers at both CalTech and the Australian National University in Canberra, had two implications not shared by the oxygen isotopic effects. The enrichment in isotopic magnesium was shown to be caused by the decay of a radioactive aluminum isotope with a half-life of only 0.7 million years, which had therefore been present in quite significant quantities in the inclusion when it was formed. Researchers had long speculated that this radioisotope was the source of the unexplained heat that metamorphosed and melted meteorite parent bodies soon after their formation. Although the quantitative role of this heat source remains to be determined, its existence is no longer an ad hoc speculation. Also, the very short half-life of isotopic aluminum threatens to upset the well-established, more than 100-million-year chronological time scale based on the extinct short-lived radioisotopes referred to earlier. It is hard to see how significant quantities of a radioisotope with a half-life of less than a million years could have survived a 100-million-year hiatus in the addition of newly synthesized nuclear material to the solar system.

The effects found in oxygen and magnesium were soon followed by

the discovery of many other isotopic anomalies in major elements, such as silicon, and in rare elements, such as barium and samarium. Some of these anomalies are of nuclear origin, others appear to be chemical; some correlate with one another, others do not.

Attempts to reconcile these new facts have led investigators to suggest that the isotopic anomalies in the Allende meteorite are carried by interstellar grains that survived the formation of the solar system. Other theorists have gone further and speculated that these grains were formed in a supernova explosion that triggered the formation of the solar system. Observational evidence for such supernova-triggered star formation has recently been found by two investigators at the Carnegie Institution of Washington's Department of Terrestrial Magnetism.

Regardless of the fate of these interesting speculations, the concept of a well-mixed homogeneous solar nebula has been badly shaken. Furthermore, still another discovery—nuggets of nearly pure noble metals in Allende inclusions—is hard to reconcile with the hypothesis that these metals were involved in condensation from a high-temperature solar nebula. The problem is explaining how these different metals could have formed at high temperature without alloying with each other.

These complex phenomena may appear to have decreased the prospect of our understanding the early solar system. More accurately, what is really happening is that theoreticians concerned with determining the evolution of stars and planets must now confront the reality of star and planet formation. Prior to the existence of these new results, the simplest explanation of the formation of the solar system was deemed the most desirable. We have now been liberated from that precept. Long ago, Faraday said, "Nothing is too wonderful to be true." The real world is turning out to be more wonderful and complex than was imagined before the evidence provided by the Allende meteorite.

George W. Wetherill is director of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.



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From the Introduction, by William A. Owens









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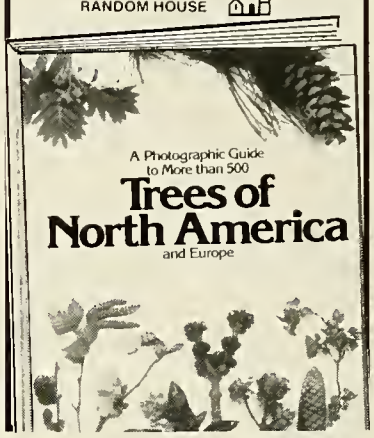


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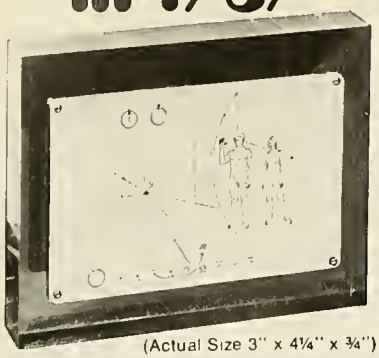
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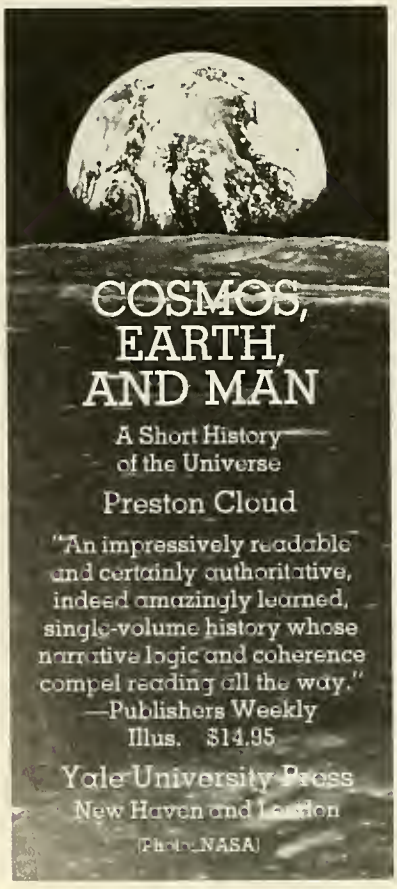
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search activities have included studies of amphibians, reptiles, albatrosses, and sea elephants, in addition to an early, continuing interest in cetaceans. For fifteen years (1951 to 1966) he was scientific director of the Zoological Society of London. A number of his whale papers—the most recent of which dates from forty years ago—are cited in the references.

In the opening chapter, "Cetology from Its Beginnings to 1945," Matthews offers a balanced, connected summary, starting with the amazing contributions of Aristotle more than twenty-three centuries ago. Then, after acknowledging the contributions of a score of intermediate naturalists, he describes the Scottish whaling captain William Scoresby as "the first scientific man to know anything about the larger whales as living animals." Matthews accurately calls Scoresby's two-volume *Account of the Arctic Regions* (1820) "of great importance [marking] a turning point in the scientific study of the oceans and their inhabitants—especially the whales." Even today most of what we know of the Greenland right or bowhead whale may be found in Scoresby's writings.

The bibliography reflects a number of scientific reports from the Whales Research Institute in Tokyo, which has published an annual report since 1948. But the papers, and the work of the Institute under the direction of Dr. Hideo Omura, receive scant mention in the text. Similarly, the contributions to our knowledge of whales of fifty-seven years of publication of the *Norsk Hvalfangsttid. (Norwegian Whaling Gazette)* are reflected in only four references. Yet as important as it is, the British contribution to the subject is generally overrated.

Matthews writes of the "dramatic noises" of the humpback whale, noting "there is no reason for supposing that they are songs in the human connotation of the word any more than are the songs of birds or cicadas or the braying of jackasses." The authors of the paper *Songs of Humpback Whales* (*Science*, vol. 173) were careful to point out that "spectrogr analysis shows . . . that a longed vocalizations occur fixed sequences and are r with considerable accurac

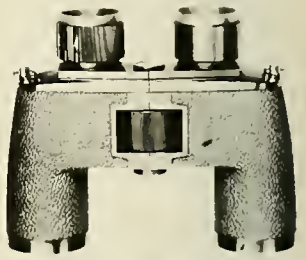
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few minutes. Because one of the characteristics of bird songs is that they are fixed patterns of sounds that are repeated, we call the fixed patterns of humpback sounds 'songs.' The principal differences between bird and humpback songs are that bird songs usually last for a few seconds, while humpback songs last for minutes. . . ." No human connotation was suggested in the paper, and Matthews's reference remains a puzzle.

In another place, Matthews refers to Scammon's Lagoon—the most northerly of the lagoons in Baja California that are mating and calving grounds of the California gray whale after an 8,000-mile migration to and from the Arctic—as "now sunk to the ignominy of a tourist attraction." Not so. The Mexican government has banned tourist boats from Scammon's for some time, although they may enter other lagoons. Visitors to San Ignácio and Magdalena numbered about 1,000 in 1978, and most showed restraint in watching whales and visiting the fragile habitats along the shore. In the last sentence of the book, Matthews castigates "the depredations of too enthusiastic whale-lovers," but nowhere does he use strong language to describe the depredations of the whaling industry.

For instance, Matthews writes, "As all the world knows, man is by far the greatest predator on the cetaceans, and *is now* by the aid of modern technology *overcropping* them [italics mine]. . . ." The "is now" phrase implies a recent phenomenon, but "overcropping" (far too quaint a word for the slaughter that went virtually unchecked until this decade) has been going forward for more than half a century.

He notes a dawning awareness of "the damage . . . inflicted upon the stocks of animals that can have an important place in [the] economy." No other value but "preserving them for future use" is part of his calculation. Even if we view whales through a strictly economic lens—not taking into account their place in the oceans' habitats, knowledge yet to be gained, and the value of the whale qua whale—the ironic fact is that recreational interest in whales (mainly through visits to aquariums but also whale watching from the edge of land and in little boats) has nearly surpassed whale killing as an economic force.



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Matthews's view of the Japanese interest in whales is out of date. He says, "Japan places more importance on whale meat than whale oil in the effort to feed its large population denied by Japanese geography an adequate home production of animal protein." Sounds good, but the facts dispute this assertion. In recent years, the baleen whales—which were taken chiefly for their meat—have dwindled to nominal importance with the exception of the little Minke whale, and the catch comprises largely sperm whales, most of which are juveniles. Sperm whale meat is not considered palatable by the Japanese, so the hunt for the remaining young sperm whales proceeds for other commercial reasons, not to provide protein for the populace.

The author questions the idea of "group feeding" among cetaceans but seems unaware of the cooperative behavior suggested by the "bubble curtain" first described by Jurasz. Humpbacks in Glacier Bay have been observed laying down a screen of bubbles to contain herring and then to feed upon them, one whale at a time, in rapid succession. Matthews does, however, skillfully debunk some prevailing hypotheses for "the strange phenomenon of mass stranding which occurs from time to time in several species of odontocetes": sonic disorientation in shallow water; parasitic worm in the middle or inner ear; obscurity of sandy or muddy water; an inexplicable panic communicated through a school. He notes that mass stranding often did not involve sudden panic but was rather a persistent, deliberate shoreward movement. An explanation emerges from one of his examples: errant or faltering leadership could contribute to mass stranding. Another example is found in a UPI newspaper account of July 29, 1976, describing a school of twenty-nine false killer whales that stranded at Loggerhead Key, Florida, behind an old leader, were pulled off shore, and then apparently followed a new leader.

On behavioral questions about dolphins, Matthews seems to have little personal experience, culling his information from a narrow stripe of published materials. For example, he refers to the "docility of dolphins toward their keepers once they have got to know them." Experience shows otherwise. The dolphin is outwardly docile from the moment of capture when it is lifted by a sling to a holding tank on the deck of a boat, but it seems to go through its entire sonic repertoire—trying to deal with an utterly traumatic experience. Dolphins are initially very shy in captivity (to call recent captives "wild" and old captives "tame" is inappropriate), and any later rambunctiousness seems to arise from interactions with humans and the tiny, sterile world of confinement.

While the author shows little interest in the whale brain (and ignores the series of impressive monographs on the dolphin brain compiled by Morgane, Jacobs, and McFarland), he writes of the whale penis with zest. The first illustration in this book, for example, is an early engraving of a sperm whale stranded at Scheveningen in the Netherlands (1598): "it does correctly show the great size of the penis, the beauties of which a gentleman is pointing out to his girlfriend; someone has long ago prudishly 'painted out' this magnificent member in the Rijksmuseum picture." Also, in referring to a work published in 1685 by John Ray, he concludes that the figure of the sperm whale is a copy of "the Scheveningen whale in all its masculinity, no doubt to the interest and ribald joy of Samuel Pepys, who paid for the engraving of the plate."

Matthews seeks by a variety of means to disparage the possibility of cetacean intelligence. For example, "Although the brain of the cetaceans is large and shows a complexity of development of the cerebral cortex, there is no reason for supposing that the cetacean capacity for learning is associated with intelligence." Much remains to be learned about the nature of intelligence in man, and yet his comment seems to contradict how we define intelligence, namely, the capacity for learning. And how can the prickly topic of intelligence be raised without mentioning the person whose work, writings, and theories got the discussion going? A medical scientist, John Lilly, has transformed the way scientist and layman alike think about whales and dolphins. The mosaic for understanding their intelligence is incomplete, but Lilly is one of those occasional persons in the annals of science who has postulated a truly

revolutionary, radical view of how we think about ourselves in relation to the natural world. The hypothesis, still not adequately demonstrated, is that we are not alone. The possibility of other intelligent species, the cetaceans, is worthy of discussion—and first-class empirical research.

In a small book it is not easy to select examples of new research and strike a balance, especially in the burgeoning field of cetacean bioacoustics. Certain important gaps do occur in Matthews's book, such as the omission of Watkins's splendid research that led to a detailed analysis of an elegant click exchange between two sperm whales. But in spite of the foregoing reservations, Matthews has written a good whale book, which is a formidable accomplishment.

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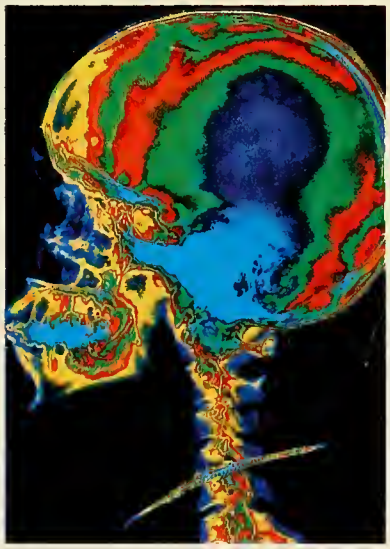
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Additional Reading

Trekking in Brazil (p. 42)

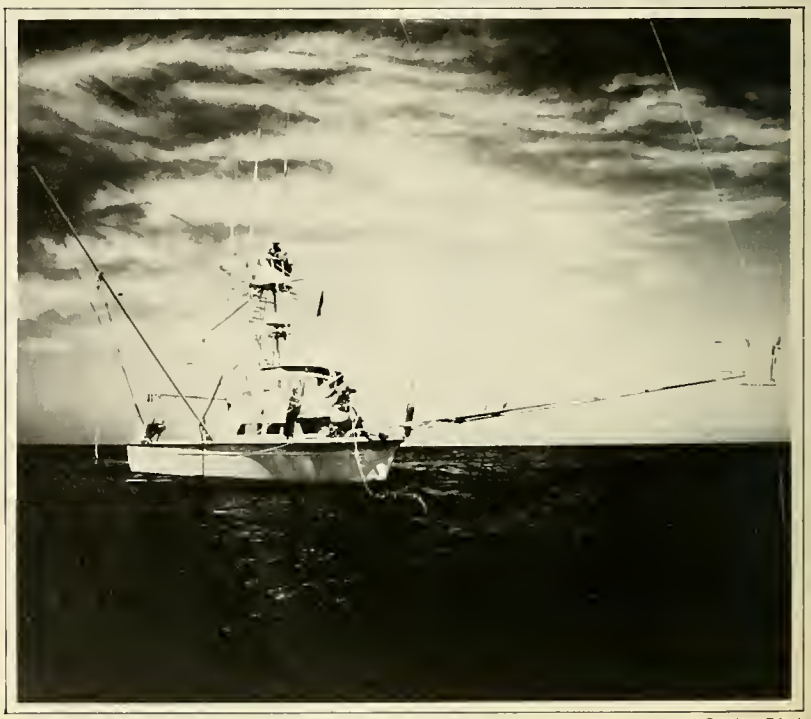
The uprooting and demise of Indian tribes caused by the economic development policies of Brazil's military regime is the subject of Shelton H. Davis's *Victims of the Miracle: Development and the Indians of Brazil* (New York: Cambridge University Press, 1977). *Amazonia: Man and Culture in a Counterfeit Paradise* (Chicago: Aldine Publishing Co., 1971) analyzes seven native cultures and how they have learned to exploit their harsh environment profitably. The author, Betty J. Meggers, is an award-winning authority on South America. *Peoples and Cultures of Native South America: An Anthropological Reader*, edited by Daniel R. Gross (Garden City: Doubleday/Natural History Press, 1973), is a collection of articles with an extensive bibliography.

Snakes (p. 56)

Although no books on venomous bites by presumably nonvenomous snakes are readily available, case reports are scattered in the medical and herpetological literature. The accounts of the fatal snakebites inflicted on Robert Mertens and Karl Schmidt can be found on pages 477–79 of *Toxins: Animal, Plant and Microbial*, edited by P. Rosenberg (Elmsford: Pergamon Press, 1978), and on pages 280–82 of "Fatal Bite of Captive African Rear-fanged Snake (*Dispholidus*)," by Clifford Pope (*Copeia*, December 22, 1958), respectively. A report of yamakagashi bites appears in "Envenomation from the Bite of the Japanese Colubrid Snake (*Rhabdophis Tigrinus* (BOIE)," by M.B. Mittleman and R.C. Goris (*Herpetologica*, pp. 113–19, June 1974). *Men and Snakes*, by Ramona Morris and Desmond Morris (New York: McGraw-Hill Book Co., 1965); *Snakes in Fact and Fiction*, by James A. Oliver (Garden City: Natural History Library/Doubleday and Co., 1963); and *Venomous Reptiles*, by Sherman A. Minton, Jr., and Madge Rutherford Minton (New York: Charles Scribner's Sons, 1969), are general books. Maurice Richardson covers classification, evolution, and anatomy in *The Fascination of Reptiles* (New York: Hill and Wang, 1972). This colorfully illustrated book includes personal experiences and a small collection of poems and prose extracts. *Poisonous Snakes of the World*, rev. ed. (Washington: U.S. Government Printing Office, 1968) is a manual sold by the Superintendent of Documents.

West Coast Fishing (p. 64)

The newest, most relevant reference is by Michael K. Orbach, who lived and worked with the tuna seiners of San Diego: *Hunters, Seamen, and Entrepreneurs* (Berkeley: University of California Press, 1978). *North Atlantic Fishermen*, Newfoundland Social and Economic Papers, no. 5, by Raoul Andersen and Cato Wadel (Toronto: Toronto Press, 1972), is one of the best collections. *Fishermen of Galilee: The Human Ecology of a New England Coastal Community*, University of Rhode Island Marine Bulletin, no. 17, by John J. Poggie, Jr., and Carl Gersuny (Kingston: Sea Grant Publications, 1974), can be obtained for $3.00 from the Marine Advisory Service, University of Rhode Island, Narragansett, Rhode Island 02882. Traditional boundary rules are discussed in James M. Acheson's "Territories of the Lobstermen," (*Natural History*, April 1972).



Stephen Frisch

Triumphant Trumpeter (p. 72)

The Trumpeter Swan: Its History, Habits, and Population in the United States, by Winston E. Banko (*North American Fauna,* no. 63, U.S. Fish and Wildlife Service, 1960), is the standard reference. Although out of print, it is available in good libraries. The best book on swans of the world is *The Swans,* by Peter Scott and the Wildfowl Trust (Boston: Houghton Mifflin Co., 1972). Paul A. Johnsgard's *Waterfowl: Their Biology and Natural History* (Lincoln: University of Nebraska Press, 1968) is arranged by topic rather than species and is abundantly illustrated. Distribution and breeding are discussed in *The Trumpeter Swan in Alaska,* by H.A. Hansen et al. (*Wildlife Monographs,* no. 26, The Wildlife Society, 1971). The illustrated *Travels and Traditions of Waterfowl,* by H. Albert Hochbaum (Minneapolis: University of Minnesota Press, 1956), deals with behavior and migration.

Bloodletting (p. 78)

Kenneth Dewhurst describes the subject of his book, *Dr. Thomas Sydenham (1624–1689): His Life and Original Writings* (Berkeley: University of California Press, 1966), as the greatest physician England ever produced. The first part of the book is historical and emphasizes Sydenham's variations in technique; the second part is an annotated collection of the doctor's writings. *A History of Medicine,* vol. 1, by Ralph H. Major (Springfield: Charles C. Thomas, 1954), is illustrated and covers the subject back to prehistory. The human need for iron is discussed in "Iron and Susceptibility to Infectious Disease," by Eugene Weinberg (*Science,* May 13, 1974, pp. 952–56).

Katharine D'Agosta



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At the Museum

New York City's newspaper strike meant that fewer casual viewers joined the devotees of anthropological films at the second annual **Margaret Mead Film Festival,** held for five days at the American Museum of Natural History in mid-September, and featuring more than 125 films. In only a year, the festival has become an important forum for anthropologists, filmmakers interested in ethnographic material, students, and others seriously interested in developments in anthropological film. The quieter character of this year's festival paralleled that of Jorge Preloran, the Argentinian filmmaker honored.

On the first three festival evenings prior to the weekend, the dignified, solid-looking Preloran personally presented some of his films, including his latest, *Zerdo's Children*. His best-known work, *Imaginero* ("The Image Maker," 1969) is extremely beautiful, a reminder that Preloran was a painter who went on to study architecture. He classifies *Imaginero* as "a portrait of a man I loved," whereas *The Warao* (1974), shown the second night, is what he considers his attempt to make an ethnographic film about a peaceful Venezuelan Indian tribe. Not all the audience agreed with Margaret Mead, who described *The Warao* as "baskets, baskets, baskets." But the film did raise questions about Preloran's seemingly omniscient and omnipresent point of view. Does he anticipate action or does he follow it? "I don't know what I do," replied Preloran, inconclusively. "The camera moves and I go with it."

Like Preloran, more filmmakers who are not trained ethnographers are being drawn to ethnographic material. Ethnographer or professional filmmaker, anyone who takes up a camera must make choices—of good cuts and of cuts that tell the truth in ethnographic terms or, increasingly, in political terms. The mixed results, and the reactions of different audiences, dominated formal and informal festival discussions, over lectern or water fountain.

Commentary reflected the history and changing nature of anthropological film, as outlined during Margaret Mead and Malcolm Arth's Saturday morning symposium on trance. The first anthropological films were either research footage or attempts to convey to the public a sense of a culture. Especially in the second case, distortions were inevitable, but could be anticipated.

The first Saturday film was Mead and Gregory Bateson's *Trance and Dance in Bali,* filmed in 1938 with techniques one observer called "hand-held Brownie." This data-gathering film tries to show exactly what happens during a particular Balinese dance whose participants go into trance, stab themselves, yet suffer no wounds.

The second film, *Bali: The Mask of Rangda* (1975), by filmmakers Harvey Bellin and Elda Hartley, shows the same dance in lush color. Its heavy emphasis on Jungian symbolism in the ritual drew salty comments from Mead, but the photography did provide details of masks and a witch's long fluttering fingernails that could not be appreciated in the earlier version. The third film, *Puerto Rican Espiritismo in the South Bronx* (1978), was made by a group of Mead's Columbia University students, who earned high marks for their respectful portrait of a medium at work.

The question of whether these recent experiments contribute to the forward march of anthropology and more accurate filmmaking dominated Mead and Arth's Sunday symposium on "Truth and Fact in Film." Mead distinguished between what she called the "American idea" of truth as a sum of known facts, and truth "in the Russian sense," an emotional certainty that transcends facts. The case in point was filmmaker Joel Freedman's *Broken Treaty at Battle Mountain* (1974), about the struggle of the Shoshone to regain rights to parts of western Nevada. Freedman became interested in the Indians' protest after learning that the Bureau of Land Management harvested piñon trees, whose nuts the tribe gathers, by uprooting them with a ship's chain studded with railroad ties and dragged between two tractors. Several facts that Freedman omitted or clouded did not weaken his case for the validity of the Indian cause.

Freedman, like many other participants, could not say what he might contribute to next year's festival. Preloran, who regularly takes several years to complete a film, is cutting a portrait of an Argentinian puppeteer. Others are trying to locate their next grant. Polly Spiegel, a young anthropologist who is studying filmmaking at New York University, predicted that anthropologists and filmmakers will have to continue discussing the pros and cons of collaboration. "Right now, there are few ethical or methodological standards for anthropological film, and these must be clarified soon."

November Events

On Wednesday, November 15, at 7:30 P.M., **Stephen Jay Gould,** who writes a monthly column, "This View of Life," for *Natural History*, will give an illustrated lecture in the Museum auditorium on "Size and Shape: Why the Moon has Craters, No Insect is Larger than a Mouse, and Tall Churches are Narrow." Admission is $2 for Associate Members and the public, free to other members.

Ann Marie Cunningham



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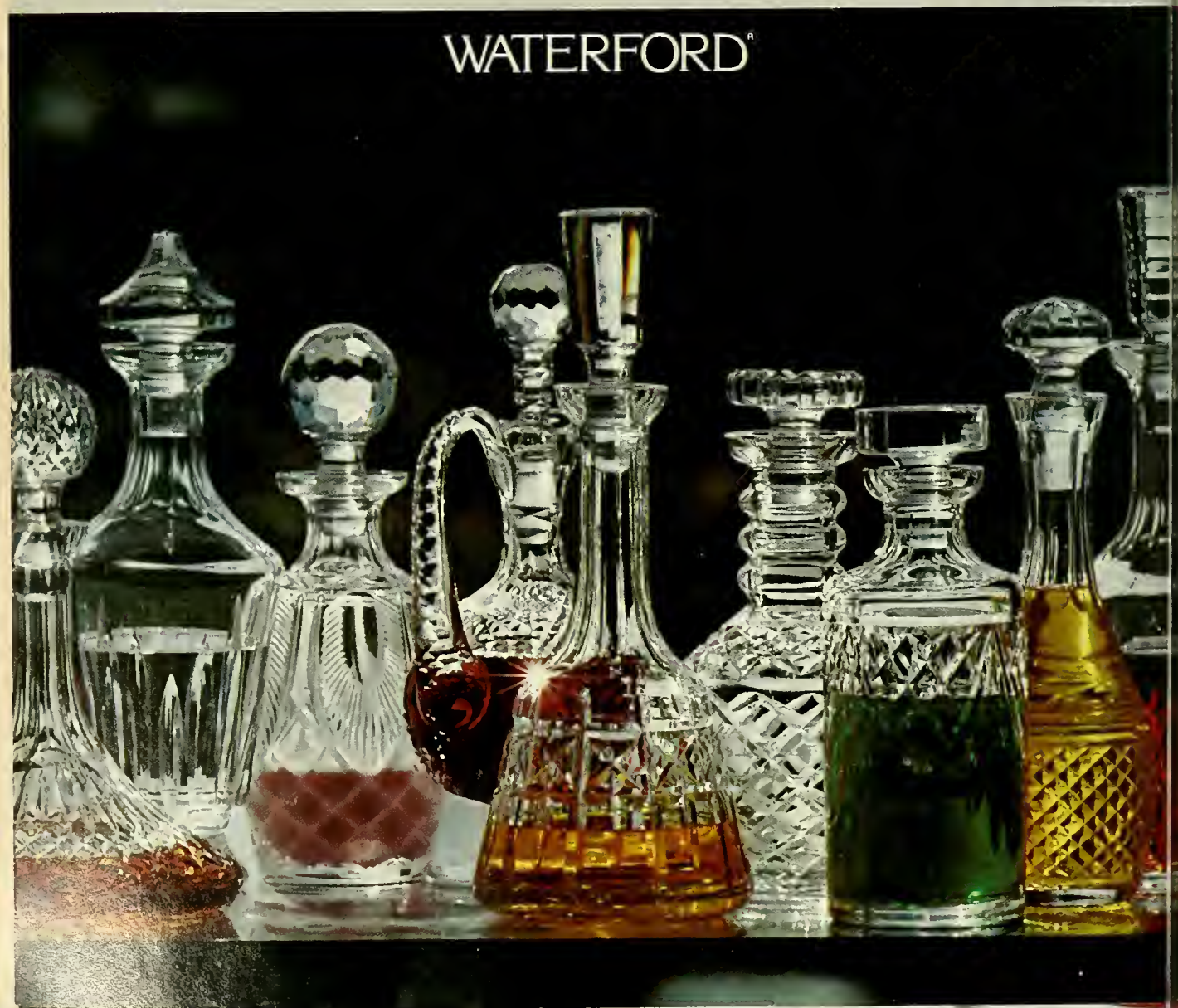
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December 1978

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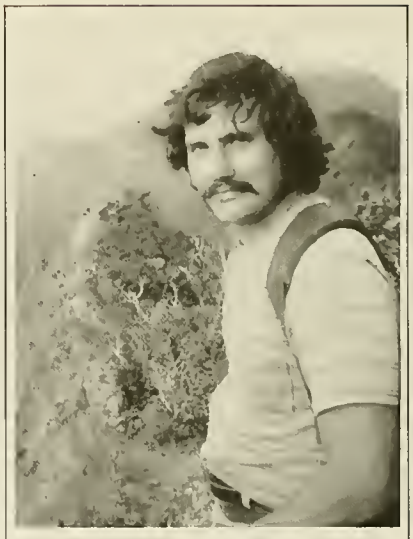
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Authors

A reporter for the *Berkshire Eagle* in Pittsfield, Massachusetts, **Stephen Fay** came upon the salmon story in the course of his regular reporting. He writes that "the town of New Marlborough, where much of the crucial work of Atlantic salmon restoration is taking place, happened to lie within my beat. When the first returnee was brought to the hatchery, I went up to check it out. Then I started to get involved." Fay, who has an M.A. in history from Holy Names College in Oakland, California, is planning to write a history of the entire effort to restore Atlantic salmon to the rivers of New England.





Alan D. Hart, who has tramped over much of the islands of Maui, Kuai, Oahu, Molokai, Lanai, and Hawaii in search of nearly extinct plants and animals, calls Hawaii "the endangered species capital of the world." He has concentrated his fieldwork on the archipelago's tree snails, particularly the genus *Achatinella*. Hart is preparing a report and petition for the U.S. Fish and Wildlife Service's Office of Endangered Species on his tree snail survey of Oahu. He writes that he will "nominate all the living species of *Achatinella* for endangered species status." Hart works as a scientific illustrator for the Smithsonian Institution, a position he previously held at the Bernice P. Bishop Museum in Honolulu.

"I like bones," says anthropologist **Erik Trinkaus,** who has worked with Neanderthal fossil remains for the past five years. In the belief that much behavioral information can be derived from the analysis of human fossils, he is busy studying skeletal remains from Huaca Prieta, Peru, to determine the influence of agriculture on the human skeleton. He also plans to engage in further excavations at Iraq's Shanidar Cave. Trinkaus obtained his Ph.D. from the University of Pennsylvania and is an associate professor in the anthropology department at Harvard University.



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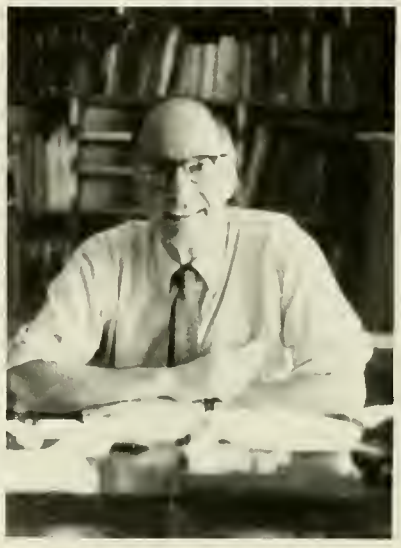
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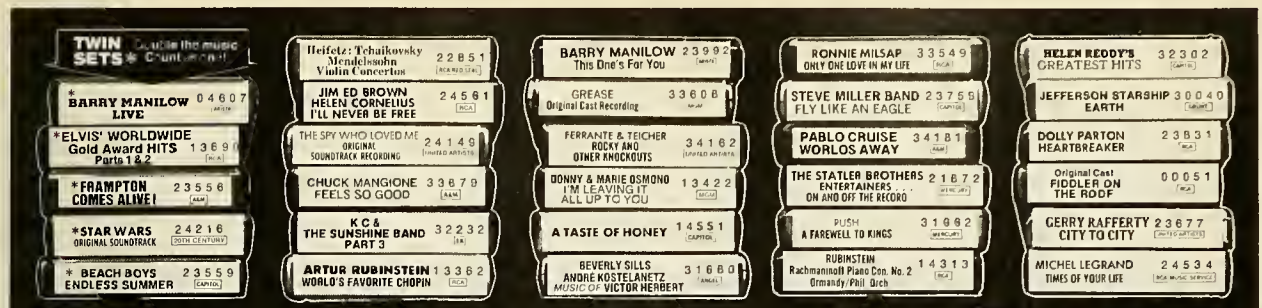


John D. Palmer has frequently contributed articles on biological rhythms to *Natural History* ("How a Bird Tells the Time of Day," March 1966; "The Many Clocks of Man," April 1970; "The Rhythm of the Flowers," August 1971). Since 1960, he has spent most summers at the Marine Biological Laboratory at Woods Hole, Massachusetts, where he is now concentrating on biological rhythms in unicells and crabs. He is chairman of the zoology department at the University of Massachusetts at Amherst, where his coauthor, **Judith E. Goodenough,** is a lecturer in zoology. She plans to move on from her studies of monthly rhythms in planarians and ant lions to look for evidence of similar rhythms in hamsters and to investigate light sensitivity in guppies.





Professor of biology at Princeton University, **John Tyler Bonner** has worked on the development of cellular slime molds since 1939. "Looking for a good organism on which to do research in developmental biology," he says, "I settled on *Dictyostelium discoideum*," a species of cellular slime mold that had been discovered only four years earlier. As part of his continuing interest in problems of evolution, he has just completed a book, *The Biological Basis of Culture*. Bonner summers in Margaree Harbor, in southern Nova Scotia, spending the time left over from writing in walking and fishing, with which he is infatuated. "La pêche est ma folie," as he puts it.



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A New Plague of Locusts

by Christopher F. Hemming

Heavy rains and war may trigger a life cycle that will launch swarms of locusts into African and Asian skies

Conditions are now ripe for a new plague of desert locusts that could extend across all of North Africa, through the Arabian Peninsula, and into India by the end of 1979. Unusually heavy monsoon and desert rainfall, civil war in Ethiopia, and the locust's own special biology make such a plague possible if not likely. This past autumn, swarms of locusts migrated westward from India to settle in Iran, Saudi Arabia, and perhaps, on the west bank of the Red Sea. Meanwhile, swarms that hatched in late summer in east Africa have bred during the autumnal rains in Ethiopia and Somalia, and their young should invade Kenya in January or February of 1979. By next summer, billions of desert locusts may be swarming toward western Africa.

The chances of a desert locust plague are not surprising to locust watchers like myself, who saw excellent breeding conditions develop during heavy rainfalls in the Mideast in October 1977. Locusts breed most successfully in wet weather, even in the light desert rains. They are blown by strong, prevailing winds to warm, damp, vegetated places where they settle, feed, and reproduce.

Although such locust-control organizations as the Centre for Overseas Pest Research and various regional groups know that a plague might be imminent, there is little they can do to counter the threat. Over the years of combating locusts in order to protect agriculture, scientists have discovered that, outside of nature itself, the most effective means of locust control is the use of aircraft to spray the insecticide dieldrin over swarms of hoppers (nonflying young desert locusts). But in 1977 and 1978, northern Ethiopia's coastal area, where the insects were breeding rapidly, was closed off to control teams by warfare between two factions fighting over Eritrea. To the southeast, the war between Somalia and Ethiopia also limited control activities. To speak anthropomorphically, one could say the desert locust could not have chosen a better time and place to begin an upsurge than Ethiopia in the late 1970s.

The first swarm of desert locusts, indicating the coming of a plague, was reported in Saudi Arabia in December 1977. Greater than usual rainfall continued and in January and February 1978, locust breeding increased in Saudi Arabia, the Yemen Arab Republic, Ethiopia, Somalia, and Sudan. Another generation appeared in March and migrated, first on the ground as hoppers and then in the air, from the shorelines into the interior. The third successful breeding in seven months came during March, April,



FAO/UN

Part of a 400-square-mile locust swarm invades farmland in Ethiopia in 1958, during the 1949–63 plague. The new outbreak may be equally serious owing to ideal breeding conditions.

and May. Some of these locusts soon migrated eastward from the Arabian Peninsula on the spring westerly winds. Ships in the Arabian Sea reported massive flights of locusts heading toward India.

Until I heard this last news, I thought the chances of a locust plague were about even. But heavy rains in the Ganges River cachment have made India and Pakistan a major breeding area. For the first time, India has requested financial aid to help control the desert locust, an indication of the seriousness of the situation.

The desert locust has long been considered one of the world's most



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So much depends on the judgment of our pruners. They must know how much to cut, at what angle and which wood. That is why we treat their training very seriously.

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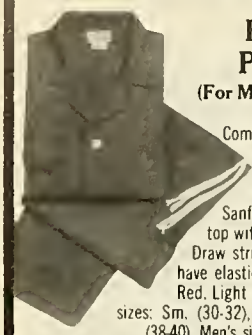
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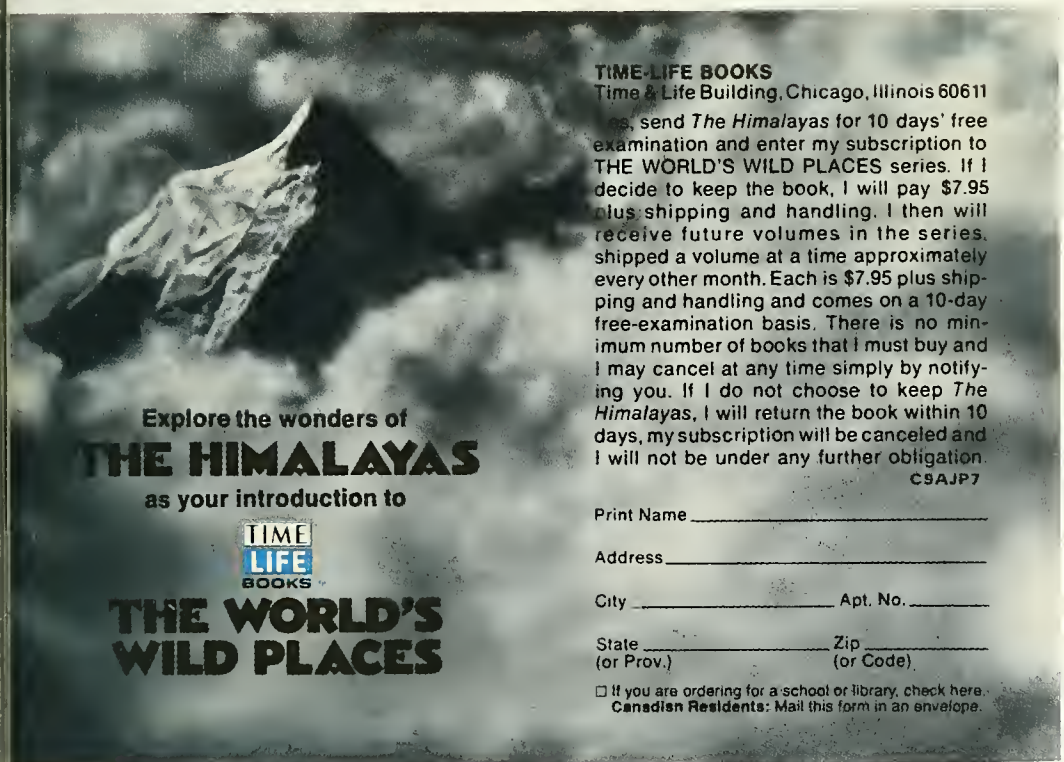
destructive agricultural pests. There are carvings of locusts on tombs built in Egypt's Sixth Dynasty (2420 to 2270 B.C.), and the Bible records that the eighth plague visited upon the Egyptians was of locusts (Exodus, chapter 10). Plagues by other species of locusts have been reported in Europe, China and other parts of Asia, and the Philippines. At the height of a desert locust plague, more than fifty countries, covering 20 percent of the earth's land surface, are at risk—from Senegal, on the Atlantic coast of Africa, east to western Burma, and from Tanzania north to the southern USSR.

A swarm consists of a leaderless pack of locusts flying at a speed of up to twelve miles per hour. The density of the pack is between 40 million and 80 million insects per 0.4 square mile. The largest swarm ever accurately measured covered almost 400 square miles and probably included 40 billion locusts. Since locusts daily eat the equivalent of their own weight—about

A newly fledged hopper dries its wings. A female locust lays 200 eggs in her four- to six-month life span. Successful incubation depends largely upon the ground's dampness.



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Israeli farmers brave a swarm in 1955. The fourteen-year plague probably began in vegetation that grew after heavy rains in the Middle East. It ended after insecticides were sprayed over breeding areas during a drought.

0.07 ounce—during their period of greatest activity, this swarm would eat 80,000 tons of food each day. This amount of corn could feed 400,000 people for a year.

Migrations of 1,000 to 3,000 miles between successive breedings are not unusual for the desert locust. The insect can fly continuously for seventeen hours and can probably stay in the air much longer if it intersperses active flight with gliding. Flight activity is greatly affected by temperature. Sustained flight is possible when the shade temperature is above 60°F with the sun shining, 75°F in cloudy conditions. The longest single flight on record by desert locusts was from the Canary Islands to Great Britain, a distance of 1,600 miles, in 1954.

Swarms usually migrate as discrete groups leaving remarkably few stragglers behind, but if it were not for the gregarious nature of individual locusts, a swarm would disperse like a cloud of smoke. Studies show that locusts on the edges are actually flying back into the swarm. This is particularly true at the front of a swarm, where locusts returning to the group form a clearly defined leading edge. At the tail end, where trailing locusts are flying in the same direction as the swarm, the edge is ragged.

"The locusts have no king, yet go they forth all of them by bands" (Proverbs 30:27). Unlike ants and bees, locusts are not social insects, and there is no leadership in a swarm. Swarms go with the wind, moving toward areas where low level winds meet and, consequently, rain falls. Thus, adult locusts are continually arriving in just those areas where the soil is moist and the vegetation green—the essential requirements for successful breeding. Although the desert locust occurs in many desert countries, it usually arrives during the rainy season, when these countries are at their least desertic.

These characteristics make the migrations of the desert locust unpredictable. A swarm may migrate to the highlands of Ethiopia or Kenya in warm weather but may not be able to leave because of a sudden spell of cool weather, so it will stay and feed for days on end until the weather warms up again. Complex wind patterns often make flying difficult even in warm weather. A swarm trapped in Morocco's Sous Valley in late 1954 and early 1955 did some $9 million worth of damage to the local citrus crop. Locusts destroy crops not only by eating them but also by breaking the branches of trees and bushes they settle on. An old Kenya farmer once told me that the sound of branches cracking under the weight of settled locusts reminded him of almost continual gunfire.

Detailed scientific studies of locusts have been undertaken only during the last one hundred years. A major revolution in the understanding of the locust problem came in 1921, when Sir Boris Uvarov first formulated the phase theory. He had been working on two insects—one was a typical locust that formed migrating swarms; the other one lived as a solitary grasshopper. Uvarov demonstrated that these insects, previously regarded as two distinct species, were really different forms of the same species. When crowded together, the grasshoppers changed their behavior to that of the locusts. Grasshoppers that were crowded together for a generation or more also changed their shape to that of the locust. Uvarov further found that the process could be reversed if the locust was isolated. He called the

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grasshopper form "phase solitaria" and the swarming locust form "phase gregaria."

Since locust plagues were periodic, many people wondered where the locusts went during the quiet spells between plagues. In these phases, now called recessions, a relatively small number of locusts still exist, but in the form of grasshoppers, with their shape and color sufficiently changed for them to be easily mistaken for that species.

The phase theory led scientists to look for regular periodicity of swarms. Biogeographical studies in India showed that plagues of the red locust and the African migratory locust had started in two small areas in Africa, which were therefore called outbreak areas. Solitary locusts live in these areas, which are seasonally flooded grasslands. Since these areas came under the supervision of international survey and control organizations, there has not been a plague of either species. No permanent outbreak area has been discovered for the desert locust, however.

The way in which desert locust plagues develop is very complex, but the two most important factors are meteorology and the gregariousness of the insect. Particular weather systems can gather nonswarming locusts together. In addition, rain in the semiarid region inhabited by the locust provides suitable breeding conditions for a large increase in population. This increase must be repeated several times, and in successive seasonal breeding areas, before enough locusts crowd together to form a swarm. As the supply of green, palatable food plants decreases toward the end of the rainy season, the locusts become even more concentrated. Eventually, a swarm develops. Plagues are unpredictable and irregular because the meteorological patterns favorable to crowding are themselves irregular.

One of the most interesting behavioral changes that occur as locusts increase in numbers is that they change from night-flying to day-flying insects. Since night temperatures in parts of the Middle East are generally well below 75°F, the temperature that desert locusts require for flight, the area locusts cover during recessions is considerably smaller than the area they cover during plagues.

During recessions, small numbers of desert locusts occur over a vast area at densities generally too low to justify any control operations by humans. There is a gradual concentration during the summer months, when rain falls in the Saharan belt. Even small areas of moist soil will provide enough moisture to sustain eggs and support the ephemeral vegetation that the young hoppers need for food and for shelter from the sun above and the hot soil below. With concentration come changes, even in small gatherings of locusts. The color pattern of the hopper begins to change from green to yellow with black markings.

During a recession, this small change probably occurs hundreds or thousands of times a year. But to be important, an alteration must occur over large areas so it can produce many gregarious locusts. Such conditions arise only when the rains are unusually heavy and widespread and attract a great many locusts. For the effect to be long-lasting, and therefore potentially serious, the next rainy season must also be good for the locusts. In areas of extremely low rainfall, the chances of having two rainy seasons in succession are small, but it does happen occasionally and can be the stimulus for an upsurge in the locust population and lead to a new plague.

A locust lays a pod containing 20 to 120 eggs, the larger number being typical of solitary locusts. Females can lay at intervals of seven to ten days, but the number of eggs per pod decreases with each laying. Many females die after laying eggs, which is why there are many more older male locusts than females.

A fair estimate would be that each female lays 200 eggs. Assuming equal numbers of males and females, there is a potential population multiplication rate of 100. With two new generations a year, the offspring of a very small swarm covering only two square miles would, within less than two and a half years, cover the entire surface of the earth. Fortunately, this never happens; a multiplication rate of ten will start a plague that can affect 20 percent of the earth's surface. At the height of a plague, a multiplication rate of two would lead to disaster.

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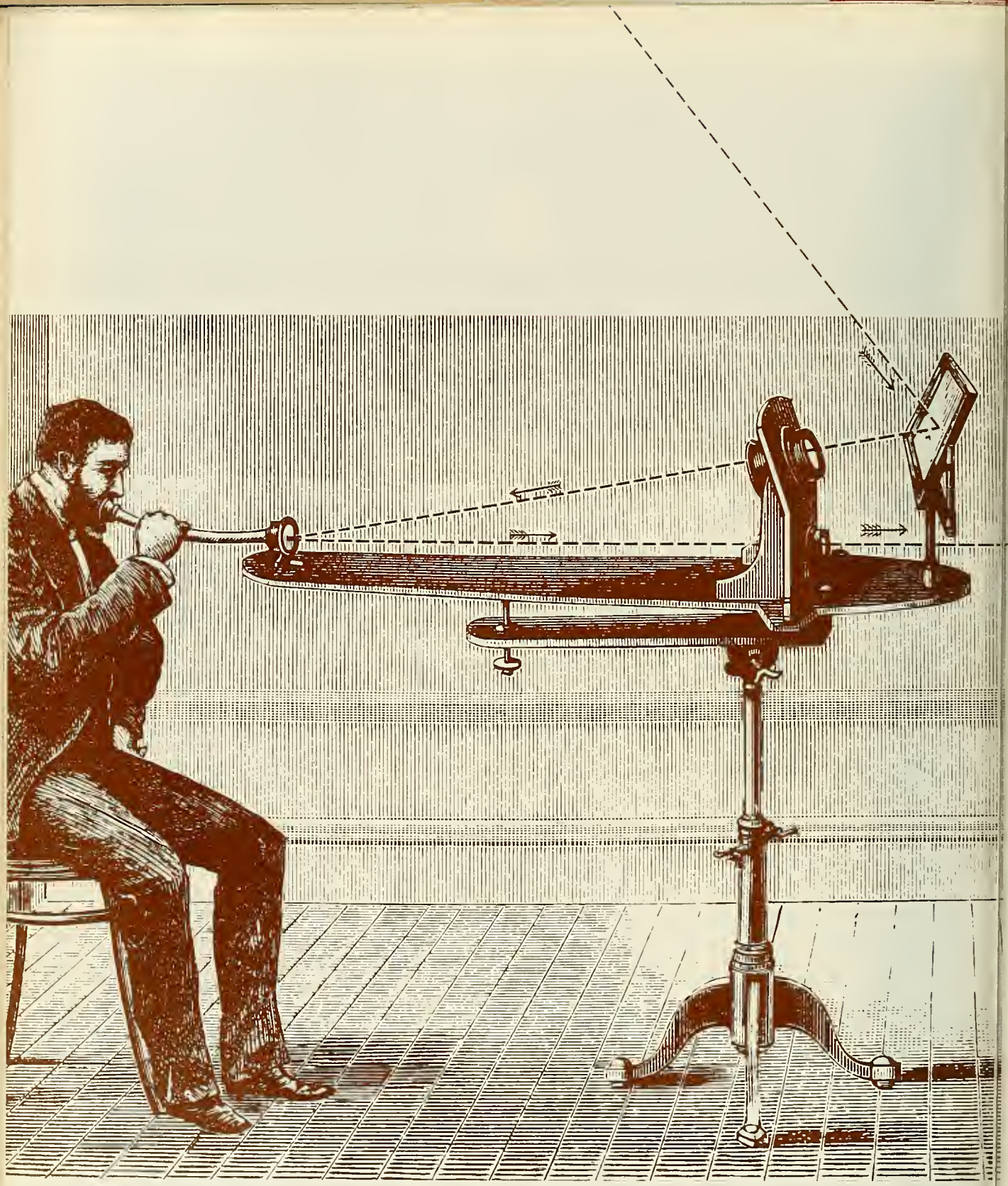
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In Bell's "Photophone," sunlight was bounced from a reflector through a lens to a mechanism that vibrated in response to speech. This caused the light beam to vary in intensity. At the receiving end, a selenium detector translated these variations into electrical current to recreate speech through a telephone receiver.

77 years before we invented the laser, Professor Bell had a perfect application for it.

In 1880, only four years after he invented the telephone, Alexander Graham Bell received a patent for a remarkable idea—using light, rather than wire, to carry phone calls.

Professor Bell built an experimental "Photophone" that transmitted his voice over a beam of sunlight. It didn't work very well, however.

Sunbeams are scattered by air, rain and fog. In any event, the sun doesn't always shine. The Photophone, unfortunately, was an idea whose time had not yet come.

A new kind of light

By the 1950's, scientists again were looking for a way to use light for communications.

In September, 1957, Charles Townes, a Bell Labs consultant, and Bell Labs scientist Arthur Schawlow conceived a way of producing a new kind of light—extremely intense, highly directional, and capable of carrying immense amounts of information.

Townes and Schawlow received a basic patent on their invention—the laser.

Since then, Bell Labs scientists have invented hundreds of lasers, including many firsts—gas and solid-state lasers capable of continuous operation, high-power carbon dioxide lasers, liquid dye lasers that produce pulses shorter than a trillionth of a second, and tiny semiconductor lasers that work reliably at normal temperatures. Some of these, no larger than grains of salt, may emit light continuously for 100 years.

Getting the light to the end of the tunnel

While we were developing lasers to generate light, we also looked for a way of shielding it and guiding it for long distances and around curves.

Extremely transparent glass fibers, perfected at Bell Labs and elsewhere, provide the answer. These hair-thin fibers can carry light many miles without distortion or the need for amplification.

In 1977, the Bell System took lightwave communications out of the laboratory and put it to work under the streets of downtown Chicago. The system, the first to carry phone calls, computer data, and video signals on pulses of light, is working successfully.

Spin-off

Laser light is now used in many other ways—to perform delicate eye surgery, detect air pollution, read product codes at supermarket checkouts, and do a variety of manufacturing tasks. Western Electric, the Bell System's manufacturing and supply unit, was the first company to put the laser to industrial use back in 1965. Hundreds of applications in many industries have followed.

Sometimes, it takes a lot of work and a long time to make a bright idea—like Professor Bell's—a reality. Often, the things we invent, such as the laser, benefit not only Bell System customers, but society in general.

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factors regularly control more than 90 percent of locust populations. Weather, parasites, disease, egg-eating predators, such as *Stomorhina* (a fly) and *Trox* (a beetle), and locust-eating birds, such as storks, all help to limit locusts. The success of a control organization during a plague is judged by its capacity to eliminate the remaining percentage, thereby keeping the locusts down to levels at which damage to agriculture is insignificant. An antilocust organization must not only save crops and, if possible, halt the plague when the locusts are swarming; it must also prevent future plagues during a recession.

Failure to control locusts in one country or region can, as we have seen, have a serious effect on another country or region thousands of miles away. Because prosperous agricultural countries that lie outside the recession area, such as Kenya, Uganda, and Tanzania, have the most to lose in the event of a plague, they cooperate with other countries in supporting regional antilocust groups. While these organizations are generally regarded as fire brigades designed to stop the situation from getting out of hand, during plagues the countries involved will throw their national resources into the battle. Some of the great dilemmas of locust control are when to act, when to appeal for funds, and most important of all, when to know that you have a plague on your hands. The unpredictability of desert locust plagues makes planning that much more difficult.

A saying among locust controllers is, "Locusts are not difficult to kill, but they are difficult to find in the immensity of the desert." Realizing the implications of the problem, the Centre for Overseas Pest Research proposed that the United States' earth resources satellite, ERTS-1, be used to identify areas where locusts might breed. If suitable breeding conditions exist, locusts will be there to take advantage of them; therefore, the initial use of the satellite was based on the identification of areas of new green vegetation. The detection of areas of wet sand without surface water would give locust control organizations even earlier warning of where to look for potential breeding sites, but finding such areas requires the use of more sophisticated equipment than has been available. The United Nations Food and Agriculture Organization is now investigating the potential use of satellites in locust control.

What can be done about the new plague of desert locusts? The answer is difficult. If a full-scale plague develops, spreading from the Atlantic to the Bay of Bengal, the problems will be logistical. Getting personnel, aircraft, vehicles, fuel, and insecticides to the right places and in sufficient quantities is especially difficult in the remote areas where locusts often breed and over which the young swarms migrate on their route to wetter, more fertile soil. We can hope that the natural factors controlling the spread of this little insect will work to keep the locust in recession.

Christopher F. Hemming is associated with the Centre for Overseas Pest Research in London, England. He has studied the desert locust for twenty-eight years in Asia, South America, and Africa.



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Locusts feed in Ethiopia in 1968. This plague, which threatened forty countries, receded after a coordinated campaign by national, regional, and international locust control organizations.

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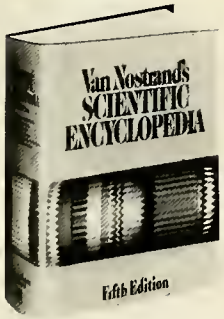
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by Stephen Jay Gould

Senseless Signs of History

Or why Londoners call a subway stop Elephant and Castle, and other interesting puzzles

There is a subway stop in the heart of London called Elephant and Castle. It honors a pub of the same name that stood for more than 300 years before its demolition in the blitz of 1942. Such an odd combination invites an obvious inquiry about its source. The pub was named for a Spanish princess, the Enfanta de Castile, whom Charles I might have married in 1625 had he been willing to become a Roman Catholic. The unfamiliar foreign words were soon transmogrified into the familiar, but pleasantly incongruous, association that survives to grace an underground system not lacking in memorable names.

Evolutionists have always viewed linguistic change as a fertile field for meaningful analogies. Charles Darwin, advocating an evolutionary interpretation for such vestigial structures as the human appendix and the embryonic teeth of whalebone whales, wrote: "Rudimentary organs may be compared with the letters in a word, still retained in the spelling, but become useless in the pronunciation, but which serve as a clue in seeking for its derivation." Both organisms and languages evolve.

This column will masquerade behind a list of curious facts, but it is really an abstract discourse on method—or, rather, on a particular method widely used but little appreciated by scientists. In the stereotyped image, scientists emphasize experiment and logic. A middle-aged man in a white coat (most stereotypes are sexist), either shyly reticent, but burning with an inner zeal for truth, or else ebullient and eccentric, pours two chemicals together and watches his answer emerge in a flask.

Hypotheses, predictions, experiments, and answers: the scientific method.

But many sciences do not and cannot work this way. As a paleontologist and evolutionary biologist, my trade is the reconstruction of history. History is unique and complex. It cannot be reproduced in a flask. Scientists who study history, particularly an ancient and unobservable history not recorded in human or geologic chronicles, must use inferential rather than experimental methods. They must examine *modern results* of historical processes and try to reconstruct the path leading from ancestral to contemporary words, organisms, landforms, and so on. Once the path is traced, we may be able to specify the causes that led history to follow this, rather than another, route. But how can we infer pathways from modern results? In particular, how can we be sure that there was a pathway at all? How do we know that a modern result is the product of alteration through history and not an immutable part of a changeless universe?

This is the problem that Darwin faced, for his creationist opponents did view each species as unaltered from its initial formation. How did Darwin prove that modern species are the products of history? We might suppose that he looked toward the most impressive results of evolution, the complex and perfected adaptations of organisms to their environments: the butterfly passing for a dead leaf, the bittern for a branch, the superb engineering of a gull aloft or a tuna in the sea.

Paradoxically, he did just the opposite. He searched for oddities and imperfections. The gull may be a marvel of design; if one believes in evolution beforehand, then the engineering of its wing reflects the shaping power of natural selection. But you cannot demonstrate evolution with perfection because perfection need not have a history. After all, perfection of organic design had long been the favorite argument of creationists, who saw in consummate engineering the direct hand of a divine architect. A bird's wing, as an aerodynamic marvel, might have been created exactly as we find it today.

But, Darwin reasoned, if organisms have a history, then ancestral stages should leave *remnants* behind. Remnants of the past that don't make sense in present terms—the useless, the odd, the peculiar, the incongruous—are the signs of history. They supply proof that the world was not made in its present form. When history perfects, it covers its own tracks.

Thus, unless some English lord or showman once displayed an elephant in his castle on the south bank of the Thames or unless some Cockney wag had an inspiration beyond my poor power to comprehend, Elephant and Castle probably began as something else—and something sensible. And why should a whale fetus make teeth in its mother's womb only to resorb them later and live a life sifting krill on a whalebone filter, unless its ancestors had functional teeth and these teeth survive as a harmless remnant.

No evidence for evolution pleased Darwin more than the presence in nearly all organisms of rudimentary or vestigial structures, "parts in this strange condition, bearing the stamp of unutility," as he put it. "On my view of descent with modification, the origin of rudimentary organs is simple," he continued. They are bits of useless anatomy, preserved as remnants of functional parts in ancestors.

But I emphasize that the general point extends both beyond rudimentary structures and beyond biology to any historical science. Oddities in current terms are the signs of history. Last month's column raised the same subject in a different context.

How to Learn About Most Job Openings in Your Field

If you are looking for a better job, there is now a single source which can tell you about most job openings as soon as they become available. It's called The National Reporter of New Job Openings, and it can assist people in all fields and locations.

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The panda's "thumb" demonstrates evolution *because* it is clumsy and built from an odd part, the radial sesamoid bone of the wrist. The true thumb had been so shaped in its ancestral role as the running and clawing digit of a carnivore that it could not be modified into an opposable grasper for bamboo in a vegetarian descendant.

In a nonbiological musing, I found myself wondering last week why *veteran* and *veterinarian*, two words with such different meanings should have a similar root in the Latin *vetus*, or "old." Again, an oddity suggesting a genealogical approach for its solution. Veteran presented no problem, for its root and its modern meaning coincide—no indication of history. Veterinarian turned out to be interesting. City dwellers tend to view vets as servants of their pampered dogs and cats. I forgot that the original veterinarians treated farm and herd animals (as do most modern vets, I guess—pardon my New Yorker's parochialism). The link to *vetus* is through "beast of burden"—old, in the sense of "able to take a load." Cattle, in Latin, are *veterinae*.

This general principle of historical

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David D. Ryus, Publisher

science should apply to the earth as well. The theory of plate tectonics has led us to reconstruct the history of our planet's surface (see my column of February 1977). During the past 200 million years, our modern continents have fragmented and dispersed from a single supercontinent, Pangaea, that coalesced from earlier continents more than 225 million years ago.

If modern oddities are the signs of history, we should ask whether any peculiar things that animals do today might be rendered more sensible as adaptations to previous continental positions. Among the greatest puzzles and wonders of natural history are the long and circuitous routes of migration followed by many animals. Some lengthy movements make sense as direct paths to favorable climates from season to season; they are no more peculiar than the annual winter migration to Florida by large mammals inside metallic birds. But other animals migrate thousands of miles—from feeding to breeding grounds—with astounding precision when other appropriate spots seem close at hand. Could any of these peculiar routes be rendered shorter and more sensible on a map of ancient continental positions? Archie Carr, world's expert on the migration of green turtles, has made such a proposal (A. Carr and P. M. Coleman, in *Nature*, May 10, 1974).

A population of the green turtle, *Chelonia mydas*, nests and breeds on the small and isolated central Atlantic island of Ascension. London soup chefs and the victualing ships of Her Majesty's Navy found and exploited these turtles long ago. But they did not suspect, as Carr discovered by tagging animals at Ascension and recovering them later at their feeding grounds, that *Chelonia* travels 2,000 miles from the coast of Brazil to breed on this "pinpoint of land hundreds of miles from other shores," this "barely exposed spire in mid-ocean."

Turtles feed and breed on separate grounds for good reasons. They feed on sea grasses in protected, shallow-water pastures, but breed on exposed shores where sandy beaches develop—preferably, on islands where predators are rare. But why travel 2,000 miles to the middle of an ocean when other, apparently appropriate breeding grounds are so much nearer? (Another large population of the same

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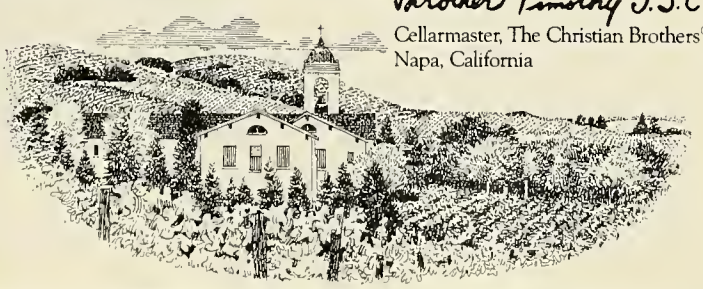
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species breeds on the Caribbean coast of Costa Rica.) As Carr writes: "The difficulties facing such a voyage would seem insurmountable if it were not so clear that the turtles are somehow surmounting them."

Perhaps, Carr reasoned, this odyssey is a peculiar extension of something much more sensible, a journey to an island in the middle of the Atlantic, when the Atlantic was little more than a puddle between two recently separated continents. South America and Africa parted company some 80 million years ago, when ancestors of the genus *Chelonia* were already present in the area. Ascension is an island associated with the Mid-Atlantic Ridge, a linear belt where new sea floor wells up from the earth's interior. Material at ridges often piles itself high enough to form islands.

Today, Iceland is the largest island formed by the Mid-Atlantic Ridge, and Ascension is a smaller version of the same process. After islands form on one side of a ridge, they are pushed away by new material welling up and spreading out. Thus, islands tend to be older as we move farther and farther from a ridge. But they also tend to be smaller and finally to erode away into seamounts, for their supply of new material is cut off once they drift away from an active ridge. Unless preserved and built up by a shield of coral or other organisms, islands will eventually be eroded below sea level by waves. (They may also sink gradually from sight as they move downslope from an elevated ridge into the oceanic depths.)

Carr therefore proposed that the ancestors of Ascension green turtles swam a short distance from Brazil to a "proto-Ascension" on the late Cretaceous Mid-Atlantic Ridge. As this island moved out and sank, a new one formed at the ridge and the turtles ventured a bit farther. This process continued and, like the jogger who does a bit more each day and ends up a marathoner, turtles found themselves locked into a 2,000-mile journey. (This historical hypothesis does not deal with the other fascinating question of how the turtles can find this dot in a sea of blue. The hatchlings float to Brazil on the Equatorial Current, but how do they get back? Carr supposes that they begin their journey by celestial cues and finally home in by remembering the character

[taste? smell?] of Ascension water when they detect the island's wake.)

Carr's hypothesis is an excellent example of using the peculiar to reconstruct history. I wish I could believe it. I am not troubled by the empirical difficulties, for these do not render the theory implausible. Can we be confident, for example, that a new island always arose in time to replace an old one—for the absence of an island for even one generation would disrupt the system. And would the new islands always arise sufficiently "on course" to be found? Ascension itself is less than seven million years old.

I am more bothered by a theoretical difficulty. If the entire species *Chelonia mydas* migrated to Ascension or, even better, if a group of related species made the journey, I would have no objection, for behavior can be as ancient and as heritable as form. But *C. mydas* lives and breeds worldwide. The Ascension turtles represent only one among many breeding populations. Although its ancient ancestors lived in the Atlantic puddle 200 million years ago, the genus *Chelonia* may not go back more than fifteen million years, while the species *C. mydas* is probably a good deal younger. (The fossil record, for all its faults, indicates that few vertebrate species survive for as much as ten million years.) In Carr's scheme, the turtles that made the first trips were rather distant ancestors of *C. mydas* (in a different genus at least). Several events of speciation separate this Cretaceous ancestor from the modern green turtle. Now consider what must have happened if Carr is right. The ancestral species must have been divided into several breeding populations, only one of which went to proto-Ascension. This species then evolved to another and another through however many evolutionary steps separated it from *C. mydas*. At each step, the Ascension population kept its integrity, changing in lock step with other separate populations from species to species.

But so far as we know, evolution doesn't work this way. New species arise in small isolated populations and spread out later. Separate subpopulations of a widely dispersed species do not evolve in parallel from one species to the next. If the subpopulations are separate breeding stocks, what is the chance that



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James Hanken, Bruce Coleman



Green sea turtle, Tortuguero, Costa Rica

all would evolve in the same way and still be able to interbreed when they had changed enough to be called a new species? I assume that *C. mydas,* like most species, arose in a small area sometime within the last ten million years, when Africa and South America were not much closer together than they are today.

In 1965, before continental drift became fashionable, Carr proposed a different explanation that makes more sense to me because it derives the Ascension population after *C. mydas* evolved. He argued that ancestors of the Ascension population accidentally drifted on the Equatorial Current from west Africa to Ascension. (Carr points out that another turtle, the west African ridley, *Lepidochelys olivacea,* colonized the South American coast by this route.) The hatchlings then drifted to Brazil in the same east-to-west current. Of course, getting back to Ascension is the problem, but the mechanism of turtle migration is so mysterious that I see no barrier to supposing that turtles can be imprinted to remember the place of their birth without prior genetic information transmitted from previous generations.

I don't think that the validation of continental drift is the only factor that caused Carr to change his mind. He implies that he favors his new theory because it preserves some basic styles of explanation generally preferred by scientists (incorrectly, in my iconoclastic opinion). By Carr's new theory, the peculiar Ascension route evolved gradually, in a sensible and predictable fashion, step by step. In his former view, it is a sudden event, an accidental, unpredictable vagary of history. Evolutionists tend to be more comfortable with nonrandom, gradualistic theories. I think that this is a deep prejudice of Western philosophical traditions, not a reflection of nature's ways. I regard Carr's new theory as a daring hypothesis in support of a conventional philosophy. I suspect that it is wrong, but I applaud his ingenuity, his effort, and his method, for he follows the great historical principle of using the peculiar as a sign of change.

I am afraid that the turtles illustrate another aspect of historical science—this time a frustration, rather than a principle of explanation. Results rarely specify their causes without some unsettling bits of ambiguity. If we have no direct evidence of fossils or human chronicles, if we are forced to infer a process only from its modern results, then we are usually stymied or reduced to speculation about probabilities. For many roads lead to almost any Rome. With only a map and the pavement over a vanished pub, who would have guessed the source of Elephant and Castle?

This round goes to the turtles—and why not? While Portuguese sailors hugged the coast of Africa, *Chelonia mydas* swam straight for a dot in the ocean. While the world's best scientists struggled for centuries to invent the tools of navigation, *Chelonia* looked at the skies and proceeded on course.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.



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Elkhart	Myers Mens Wear
Ft. Wayne	Beakin
Ft. Wayne	Maier
Ft. Wayne	Meyers & McCarthy
Ft. Wayne	Montgomery's
Goshen	Snyder's Mens Shop
Greencastle	Mac's
Hammond	Arnold J's
Highland	Lewin's
Indianapolis	Arnold's
Indianapolis	Edrich Ltd.
Indianapolis	Fogels
Indianapolis	Hudson's
Kokomo	Bealls
Kokomo	Maher's
Marion	Milten's Clothes
Michigan City	Blake's
Michigan City	Carson Pirie Scott & Co.
Muncie	Bealls
New Albany	P.A. Niemaier
New Castle	Lloyd Beall
Richmond	Loehr's
Seymour	Dell Bros.
South Bend	Gilbert's
South Bend	Rasmussen's
South Bend	Village Gentry Shop

IOWA

Ames	Durham & Durham
Burlington	Palace Clothiers
Burlington	J. Stevens
Cedar Falls	Palace Clothiers
Cedar Rapids	Armstrong's
Cedar Rapids	Holley's
Des Moines	Bond's
Des Moines	Kucharos
Ft. Dodge	Eddie Duinn
Keokuk	Palace Clothiers
Marshalltown	Kenagy's
Sioux City	Black Knight
Sioux City	Mereys-Raymonds
Waterloo	Palace Clothiers

KANSAS

Great Bend	Brentwood Ltd.
Overland Park	Jerry Leonard
Overland Park	Louis Barry Ltd.
Overland Park	The Jones Stores
Overland Park	Mailliard's
Prairie Village	The Jones Stores
Prairie Village	Mailliard's
Topeka	Ray Beers
Wichita	Dillard's
Wichita	Henry's
Wichita	Jerry Leonard

KENTUCKY

Hopkinsville	Wades
Paducah	Tred Shop

LOUISIANA

Alexandria	Caplan's
Alexandria	Weiss & Goldring
Baton Rouge	Arthur's
Baton Rouge	Cohn-Turner
Baton Rouge	Todd Garland & Co.
Baton Rouge	Goudchaux's
Baton Rouge	The Varsity Shop
Bossier City	Pepe's
De Ridder	Standard Mercantile
Houma	Godchaux's
Houma	Earl Williams
Lafayette	Abdalla's
Lafayette	Gaidry's
Lafayette	Emile Joseph's
Lake Charles	Gaidry's
Lake Charles	Love's
Monroe	Haneline's
Monroe	The Toggery
Morgan City	Du Rai's
Natchitoches	Caplan's
New Iberia	Abdalla's
New Orleans	Godchaux's
New Orleans	Porter's-Stevens
Shreveport	Davis'
Shreveport	Jordan & Booth
Thibodaux	Johnny's

MAINE

Bangor	Benoit's
Bangor	Allan Lewis
Bangor	Henry Segal
Bangor	Sleeper's
Brunswick	Benoit's
Lewiston	Benoit's
Portland	Benoit's

MARYLAND

All Stores—Woodward & Lothrop

Annapolis	Peerless Clothing
Baltimore	Gage Clothes
Baltimore	Hamburgers
Baltimore	Hutzler's
Bethesda	Lawrence Reed Ltd.
Frederick	The Young Men's Shop
Hillcrest Hgts	Lawrence Reed Ltd.
Lutherville	Andrew's
Pikesville	Max Margolis
Rockville	Larry Alan
Rockville	Lawrence Reed Ltd
Salisbury	Hutzler's
Salisbury	Ralph & Gaskill
Silver Spring	David's
Towson	Andrew's

MASSACHUSETTS

Braintree	Milton's
Braintree	Natan's
Chestnut Hill	Milton's
Chicopee	Balakier's
Haverhill	Berratts
Holyoke	Zal's
New Bedford	Sullivan Brothers
New Bedford	M.C. Swift
Pittsfield	Berkshire Hills Shop
Plymouth	Puritan Clothing Co.
Southbridge	David Lenti
Springfield	Steiger's
Stoughton	Martin Edwards Ltd.
Waltham	Grover Cronin
West Springfield	Yale-Genten

MICHIGAN

All Stores—Gsmun's

Ann Arbor	Chelsea
Ann Arbor	Wild's
Bay City	Marvin's
Birmingham	Crowley's
Burton	Binder's Big Men Shop
Davison	Binder's Big Men Shop
Dawson	Homer Hill
Dearborn	Chelsea
Detroit	Crowley's
Detroit	Leclair
Farmington	Crowley's
Farmington	Hank's
Fenton	The Haberdashery
Flint	Marvin's
Flushing	Homer Hill
Grand Rapids	Captains Quarters
Grand Rapids	Jurgens & Holtvluwer
Grand Rapids	Wm. Klein
Grand Rapids	Klothes Kloset
Grand Rapids	A. May & Sons
Grand Rapids	Rogers Dept. Store
Holland	Ambassador Shop
Holland	Lokker-Rutgers
Kalamazoo	Kool & Knapper
Kalamazoo	Jud Knapper
Lansing	J.W. Knapp
Lansing	A. May & Sons
Livonia	Crowley's
Marquette	Palace Clothiers
Midland	Mesler's
Monroe	Prince George
Mt. Clemens	Teck & Marks
Mt. Pleasant	Ken's
Muskegon	Vet's Clo.
Northville	Lapham's
Saginaw	Binder's Big Men Shop
Saginaw	Edward's
Saginaw	Van Horn's
Southfield	Jonathan's
Southfield	Van Horn's
Southgate	Chelsea
Sterling Hgts	Crowley's
Stevensville	Village Gentry Shop
Wyandotte	Chelsea

MINNESOTA

Brooklyn Center	Jerry Leonard
Burnesville	Cedric's
Detroit Lakes	Norby's
Duluth	Livingsten's
Duluth	M&K Man
Duluth	Wilson's
Edina	Cedric's
Mankato	Wilson's
Minneapolis	Brown's Clothing
Minneapolis	John A. Chaix
Minneapolis	Liemandt's
Minneapolis	Jerry Leonard
Minnetonka	Cedric's
Moorhead	Northport Clo.
St. Paul	Field-Schlick
St. Paul	Jerry Leonard
St. Paul	Liemandt's
Willmar	Tergerson Clo.
Worthington	Leutheld's

MISSISSIPPI

All Stores—McRae's

Biloxi	Gayfer's
Biloxi	Gedchaux's
Biloxi	Gene Kerr's
Brandon	Busick & Son
Canton	Perlinsky's
Clinton	John's Mens & Boys
Columbus	Reed's
Greenville	Sherman's
Greenwood	Star Tailors
Hattiesburg	Waldoff's
Jackson	Gayfer's
Jackson	The Mens Shop
Jackson	Lewis Wilson
Laurel	Elird's
Laurel	Hamilton Graves
Magee	McAlpin's
Meridian	Marks-Rothenberg
Meridian	Harry Meyer
Tupelo	Rags For Men
Tupelo	Reed's
Vicksburg	Karl's

MISSOURI

Cape Girardeau	Howard's
Indepehoence	Jerry Leonard
Independence	Peter's
Jefferson City	Thomas Jefferson's
Kansas City	Indin's
Kansas City	The Jones Stores
Kansas City	Jerry Leonard
Kansas City	Mailliard's
Kirksville	Mister Jim's
Mexico	Hagan's
St. Louis	Boyd's
St. Louis	Herman's Toggery
St. Louis	The Squire's Shop
St. Louis	Wolff's Clothiers
Springfield	Dillard's

MONTANA

Billings	Dahle's B&T
Billings	Hart-Albin
Great Falls	Kaufmans

NEBRASKA

All Stores—Brandeis

Hastings	Ben Sherman's
Lincoln	Ben Simon's
McCook	Vogue Clo.
Omaha	Landon's
Omaha	Jerry Leonard
Omaha	Ben Simon's

NEVADA

Las Vegas	Harris & Frank
Las Vegas	Silverwoods
Reno	Dahle's B&T

NEW HAMPSHIRE

Concord	Mark E. Ltd.
Dover	Morton's
Manchester	Milton's

NEW JERSEY

All Stores—Field Bros.
All Stores—Jack Lang Clothes

Bound Brook	Archie's
Bridgeton	The Enterprise
Burlington	Polsky's
East Brunswick	Millers-on-the-Mall
New Providence	Adam's
Newark	Harry's Mens Shop
Red Bank	Clayton & Magee
Ridgewood	Fiorilla
Ridgewood	Mac Hugh
Sparta	Sparta Mens Shop
Summit	Walters
Vineland	Dom Micheels
Westfield	John Franks
Willingboro	Stanford-Reed

NEW MEXICO

Albuquerque	Jalen's Big & Tall

NEW YORK

All Stores—Field Bros

Albany	Fish's
Albany	Spector's
Auburn	Homick's
Buffalo	Kleinhans
Buffalo	Riverside Mens Shop
Fishkill	Al Weiss Clothes
Huntington	Marsh's
Johnson City	Hike's
Newburgh	Al Weiss Clothes
North Syracuse	Gary's Clo.
Norwich	Winan's
Port Washington	Chadow Bros.
Schenectady	Simon's Mens Shop
Southampton	Harry Frank
Spring Valley	Hat Kaplan
Staten Island	Garber's
Syracuse	Gary's Clo.
Troy	Kelly Clothes
Yonkers	Lubin's

NORTH CARDLINA

All Stores—The Hub

Charlotte	Harris-Hart
Durham	The Young Mens Shop
High Point	Wright's
Raleigh	Barrett & Edwards
Raleigh	Coleman-Wemble
Rosenbloom Mt	Rosenbloom-Levy
St. Pauls	Joe Sugar's
Shelby	Ley's Men's Shop

NORTH DAKOTA

Fargo	Northport Cte.
Fargo	Streus Co.
Grand Forks	Streus Co.
Jamestown	Streus Co.
Valley City	Straus Co.

OHIO

Akron	Lang's
Canton	The Harvard
Cleveland	B.R. Baker
Cleveland	Bill's Clothes
Cleveland	Short Sizes
Cleveland	Shuttler's
Columbus	Walkers
Dayton	Rike's
Dayton	Walkers
Findlay	Beltz Clothing
Findlay	The Toggery
Lima	Hofeller Hiatt & Clark
Marion	The Toggery
Toledo	Diamond's
Toledo	The Lion Stores
Wooster	Barney Lehman's
Zanesville	Larry Wade Ltd.

OKLAHOMA

All Stores—Dillard's

Ada	Black's
Muskogee	S&D Clothiers
Muskogee	C.J. Teels
Norman	Harry Hoelscher's
Oklahoma City	John A. Brown
Oklahoma City	Hyroop's B&T
Oklahoma City	International Fashions
Tulsa	Hyroop's B&T
Tulsa	Read's Dept. Store
Tulsa	Topper's
Tulsa	Vandever's

PENNSYLVANIA

All Stores—Jack Lang Clothes
All Stores—Morville

Allentown	Kuhns & Shankweiler
Beaver Falls	Lisia T. Miller
Bethlehem	Geoshin's
Easton	Mays
Erie	Isaac Baker
Greensburg	Carlton Mens
Greensburg	Gongaware & Long
Hanover	Trone & Weikert
Indiana	Brody Bros.
Johnstown	Carlton Mens
Johnstown	Miller's
Lancaster	Seyres Scheid & Sweeten
Latrobe	Mike Hughes
Media	B. Gross
Monroeville	Carlton Mens
Philadelphia	Fleet's
Philadelphia	Scott & Hunsicker
Pittsburgh	The Coach House
St. Marys	Ivan's
Washington	Sol Mintz
Williamsport	Ulman Bros.

RHODE ISLAND

Barrington	Hanson's
Garden City	St. Onge's
Providence	Montecello's
Providence	Outlet Co.
Warwick	St. Onge's
West Warwick	St. Onge's
Westerly	Kenyon's

SOUTH CARDLINA

Columbia	Belk

SOUTH DAKOTA

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Sioux Falls	Herman's
Sioux Falls	Wilson's

TENNESSEE

Memphis	Beasley-Jones-Ragland
Memphis	Cashen-Wright
Memphis	James Davis
Memphis	Goldsmith's
Memphis	I. Rosen
Memphis	Wilbanks & Everett
Union City	Bennetts

TEXAS

All Stores—Dillard's
All Stores—Frank's King Size

Abilene	F&S Clothiers
Amarillo	Blackburn Bros.
Amarillo	Coel's Clothiers
Amarillo	Colberts/Harry Holland
Austin	Clyde Campbell
Austin	Merritt Schaefer & Brown
Beaumont	Joske's
Big Spring	Gibbs & Weeks
Bryan	Gentleman's Quarter
Corpus Christi	Winsteads'
Corsicana	Harris & Jacobs
Dallas	Best & Martin
Dallas	Clyde Campbell
Dallas	L.O. Hammons
Dallas	Hyroop's B&T
Dallas	Irby-Mayes
Dallas	Murray's Men's Shop
Dallas	Tall-E-Ho
Dallas	Jas. K. Wilson
Denson	L.O. Hammons
Denson	Lilley's
Denton	Bomar's
Ft. Worth	Clyde Campbell
Ft. Worth	L.D. Hammons
Ft. Worth	Jack Howard
Ft. Worth	Tall-E-Ho
Ft. Worth	The Village Squire
Ft. Worth	Jas. K. Wilson
Greenville	L.O. Hammons
Groves	Dryden's
Henderson	Earl's
Houston	Foley's
Houston	Hyroop's B&T
Houston	Joske's
Houston	Leopold, Price & Rolfe
Houston	Norton Ditto
Houston	Rbdney's
Humble	Priddy's
Hurst	Watson's
Jacksonville	Ron Moore's
Kilgore	Hurwitz Man's Shop
Lamesa	Collins
Longview	Hurwitz Man's Shop
Longview	Turpie Slade
Lubbock	Hemphill-Wells
Lubbock	Reed's
Lubbock	S&D Clothiers
Lufkin	Blackstock's
McAllen	Christopher's
Midland	Grammar-Murphey
Nacogdoches	Jimmie Simms
Odessa	Jim's Tall & Big Man's
Odessa	Melvin's Clothiers
Odessa	The Model Shop
Pasadena	Nolan's
Perryton	Saied's Mens Wear
Plainview	Marse & Son
Rockwall	Wolfgang's
San Angelo	Crowder's
San Angelo	Mr. Sam's
San Antonio	Pate's
Sherman	The Gentry
Sherman	Tepper's
Snyder	The Haberdashery
Stamford	Hind's
Stephenville	Christian Bros.
Tyler	Hurwitz Man's Shop
Tyler	J. Massad's
Uvalde	Rowland's
Vernon	Clayton's
Victoria	Melvin's
Waco	Cox's
Waco	Holt's

UTAH

Ogden	Dahle's B&T
Ogden	Tanner Clo. Co.
Orem	Dahle's B&T
Salt Lake City	Auerbach
Salt Lake City	Dahle's B&T
Salt Lake City	Arthur Frank

VERMONT

Burlington	Hayes & Carney
Burlington	Nates

VIRGINIA

All Stores—The Hub
All Stores—Shulman's
All Stores—Woodward & Lothrop

Arlington	The Quality Shop
Blacksburg	Joseph Davidson
Charlottesville	The Young Men's Shop
Crystal City	Gentlemen Joe's
Parksley	Watts Bros.
Petersburg	Adolph's
Richmond	Franco's
Roanoke	Joseph Davidson
Springfield	Ted Louis Shop

WASHINGTON

Bellevue	Michael Patrick

WEST VIRGINIA

Beckley	Lilly's
Charleston	Kelley's
Princeton	The Stag
Wheeling	Crone's

WISCONSIN

Appleton	W.A. Close
Eau Claire	H&L Mens Shop
Green Bay	Wilson's
Kenosha	Chiappetta's
Kenosha	Greening's
Lacrosse	Newburg's
Madison	Baskin/Olson & Veerhusen
Milwaukee	Gieringer's
Milwaukee	Heitzman's Big & Tall
Milwaukee	M. Hyman & Son B&T
Milwaukee	Myer-Krom
Milwaukee	Schmitt-Orlow-Stumpfs
Oshkosh	W.A. Close
Racine	Jorgensens
Rhinelahoer	DeByle's
Sheboygan	Kress-Hertel
Wausau	St. Claire
West Alis	Modern Clo.

PUERTO RICO

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Jaymar-Ruby, Inc., Michigan City, Indiana

by Raymond Sokolov

Liver Trouble

Is there any reason for the strong culinary aversion to this organ?

Of all the hated foods, liver probably repels more people than any other. There is some justification for this widespread antipathy. Calf and beef livers are large, bloody organs, enormous smooth-textured glands with mysterious functions and a strong and, therefore, threatening taste. Most cooks add to the liver's unpopularity by overcooking it until it turns stiff and gray. They usually do not trim off the outer membrane beforehand, so that when this thin outer "rind" contracts under heating, it tightens around the meat and makes it curl inward in an ugly pucker.

All of these practical drawbacks are only the beginning of the liver's troubles. Primitive, and many not so primitive, peoples have thought that this dark, bile-producing gland (at 40 to 60 ounces, the most massive of all human glands) was the seat of the passions. It has long been obvious that life cannot go on without a liver to perform various vital functions, notably the conversion of sugar to storable glycogen. The liver is also a repository of large amounts of vitamin A, iron, and other crucial nutriments, but these were not the reasons behind the liver's awesome reputation among prescientific folk.

It takes no great leap of the imagination to grasp why hunting nomads would regard the liver as a source of manhood, of brooding, chthonic energies. I felt this more surely than ever while lunching a while back in the top floor restaurant of the World Trade Center in downtown Manhattan. I was there on a journalistic mission whose pleasant side effect was a meal with the chef at a table 107 stories above the Hudson. Under such circumstances, it is boorish to ask for the menu, and on this particular occasion—it was late fall and the hunting season was in full swing—the chef offered me a taste of the deer he had shot upstate the day before. He offered me, in fact, the greatest delicacy he could carve from his noble quarry—the liver. With perhaps excessive modesty, he excused himself from cooking the prized morsel. He served it raw, red-purple, and crunchy.

Liver always requires us to adopt a special standard of taste if we are going to eat it with gusto. This was abundantly true of the slice of deer liver I ate, with increasing delectation. The first forkful, I admit, was an eyes-closed vault into the abyss. Soon, however, I could see that all was well. I was tasting the most *macho* of meats in a way that brought me in symbolic touch with Apache chieftains and Mongol raiders.

No doubt this fantasy will not appeal to many readers. And I have no wish to convert anyone to raw stag liver. But the experience was a key to the paradoxical nature of all liver for, like the ancient strongman Milo of Crotona—who could hold a ripe fruit so tightly in his hand that no one could pry it loose but, at the same time, so daintily that he never damaged the fruit—liver is a combination of power and gentleness, of softness of texture and boldness of taste.

Rapid cooking is the prime secret for exploiting these antipodean virtues. The outstanding recipe for achieving this essential result is *fegato alla veneziana*, liver in the Venetian manner. This dish is liver and onions raised to the highest level of refinement. The process involved is almost Chinese, with its emphasis on fine slicing and quick frying in oil. In her classic description, Elizabeth David recommends the tenderest calf's liver, "so soft that you could put a finger through it as if it were bread." Thin strips of this elite liver are then added to a skillet of equally thinly sliced, sautéed onions, and cooked for a minute on each side. The slicing expedites the cooking process and minimizes any toughness that might be caused by the liver's internal structure. The onions, which are there in great profusion, exude a surprising sweetness that masks any bitterness in the liver.

Although Venetian-style liver and many other excellent liver recipes are quite practical in America, most of us rarely eat calf's liver except in the conventional three ways it is usually cooked in this country—sautéed, broiled, or chopped into a paste, which is then variously enriched and flavored. For the full calf's liver repertoire, one must look farther afield, for instance, to the Ticino district of Switzerland, where Italian is spoken. At Bellinzona, a picturesque provincial capital with some stunning old buildings, an entire

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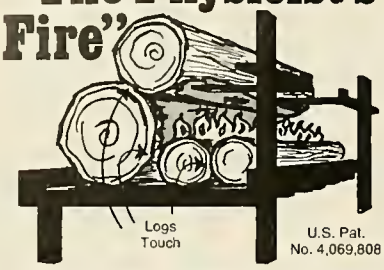
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(August, 1978, pp. 142–146)

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piece of liver is braised slowly in wine flavored with prosciutto and served with mashed potatoes and braised onions. In Zurich, they sauté fingers of liver on skewers. Each liver piece is topped with a sage leaf and wrapped in bacon before it goes on a skewer. German-speaking Switzerland shares liver dumplings with the rest of the Teutonic world. Alice B. Toklas came across a recipe for these forceful liver balls that seems to have come from Alsace but may have been Belgian (see recipe below) and has the unprepossessing name *kneppes*.

Although every one of these dishes is a success in terms of taste, the plainness of most liver preparations works against their popular acceptance. Energetic mothers, who want to sidestep the usual complaints and tempt their youngsters with a truly glamorous liver dinner, might consider trying the masterpiece that Michel Guérard recommended to dieters in his *Cuisine Minceur*. I refer to steamed calf's liver with leeks in sweet-and-sour sauce. Guérard steams a foil-wrapped, two-pound piece of liver over chicken stock for thirty minutes. The leeks are braised separately. There is also an elegant wild mushroom garnish. When all this is served, the liver is sliced like a small roast or steak.

If this seems like falderal to you, there is always haggis to fall back on. For centuries, Scots have smacked their lips over this pudding of lamb liver, heart, and lungs cooked in the stomach of a lamb (or sometimes a calf). For some reason, whose discovery I leave to the more daring adepts of structuralism, this same enthusiasm for ovine offal also crops up in Martinique, where it is called *patte en pot*, or "paw in the pot" (quite often, this stew's name is corrupted to *pâté en pot*, but it is no pâté). The Antillean cook traditionally procures the feet, the liver, the paunch (the rumen, or first stomach), the head, tripe, and heart of a sheep and sets about making a boneless stew of magisterial intensity, flavored with an encyclopedia of local vegetables, spices, and peppers. If this sounds like rough fare, I can only insist that *patte en pot*, as prepared by the redoubtable Vava in Grande-Rivière, is the very opposite of crude. Martinican gourmets are said, by the great Antillean gastronome André Nègre, to dispute whether adding bacon to *patte en pot* may not overpower the dish's basic refinement of taste.

Patte en pot is probably too exotic for casual presentation to most guests. *Grpanouk*, however, is another story. As Sonia Uvezian explains it in her *Cooking from the Caucasus*, this roast lamb shoulder from Armenia is stuffed with a recondite mixture of lamb's liver, almonds, cardamom, and rice.

Pigs, too, have livers. Used mainly for cat food in this country, they are a major ingredient in country pâtés in France. More intricately, both British and French cooks wrap pork liver mixtures in the lacy membrane known as caul fat. These little bundles are called faggots or gayettes.

Moving right along down the great chain of hepatic being, we come inevitably to chicken livers. The Chinese prize the liver more than any other part of the bird. In Szechuan, they stir-fry them with long hot green peppers. With no less reverence, modern French chefs, such as Paul Bocuse, have revived one of the legendary dishes celebrated by Brillat-Savarin, the *gateau de foies blondes*, an egg-thickened liver "cake," which when bathed in a crayfish sauce, is rightfully referred to as "one of the beatitudes of *gourmandise*."

Duck livers have also inspired magniloquence. They are excellent in pâtés, unctuous in mousses. The Chinese pay them the honor of a special course in Peking's famous all-duck restaurant.

All this liver rhetoric pales beside the encomiums that epicures have showered upon the grotesquely fattened liver of the goose, that swollen and roseate marvel called *foie gras*. "Fat liver" can actually be produced by ducks or geese, but the most common victim of this gastronomic sadism is the goose.

Around Strasbourg in Alsace and in the southwest of France, as well as certain other foreign countries (*foie gras* manufacture is illegal in the United States), geese are held immobile and literally force-fed, traditionally with corn, through a tube implanted in their throats. Eventually, their livers hypertrophy. Weights as high as 4½ pounds have been achieved.

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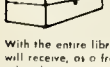
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served plain and lightly cooked, it is known as *foie gras frais*, "fresh" *foie gras*. In whatever way it is presented—inside a loaf of brioche or in one of the many other classic dishes and sauces listed in chef's manuals—fresh *foie gras* is a superlative raw material, a freakish but wonderful thing, soft as butter, complex as a fine sauce. It is sometimes available in this country, but virtually all the *foie gras* sold here is in processed forms, mousse or pâté or parfait. These are all quite disappointing adulterations. To eat the real thing, which does not keep for many days, even after cooking, one almost has to go to France. And it has been no small part of the genius of the *nouvelle cuisine* chefs to see that, by stressing *foie gras* (and other strictly local French products), they could continue to draw customers from abroad, even after the classic methods of French cooking had spread round the globe.

Michel Guérard, in *La Cuisine Gourmande*, devotes a whole chapter to *foie gras*. You could call it the height of liver literature. It ends with a typically Guérardian dish of "sumptuous rusticity," a *foie gras pot-au-feu*. This turns out to be a monument of staged simplicity: cabbage, noodles, and other vegetables making a sort of farmhouse stew ornamented with slices of freshly poached *foie gras*. Guérard does not forget to add a helpful suggestion to home cooks who might try this extravaganza of plainness. He suggests that we save the *foie gras* cooking liquid, skim off the fat, poach eggs in it and serve it as a soup. Liver, you see, is always practical.

Kneppes

(Liver dumplings, adapted from a recipe in *The Alice B. Toklas Cook Book*)

1 pound calf's liver, trimmed and chopped
3 shallots, peeled
1 clove garlic, peeled and minced
2 tablespoons butter for sautéing
Salt
Pepper
3 tablespoons flour
1 pinch mace
2 whole eggs, separated
½ cup (4 ounces, or 1 stick) butter, heated until lightly browned
2 tablespoons dry bread crumbs

1. Set a large pot of salted water to boil, covered.
2. Chop, blend, or process the liver and the shallots into a paste.
3. Brown the garlic clove lightly in the butter.
4. Mix the liver-shallot paste together with the garlic and its cooking butter, the flour, mace, and salt and pepper to taste.
5. Mix in the egg yolks one at a time.
6. When the water starts to boil, beat the egg whites until stiff but not dry. Fold them into the liver mixture.
7. Drop spoonfuls of the mixture into the boiling water and cook for ½ hour.
8. Drain the dumplings thoroughly.
9. Place on a serving dish. Pour the browned butter and bread crumbs over them.

Yield: Four to six servings

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.



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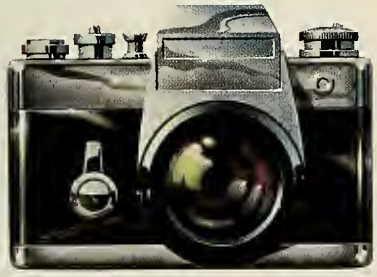
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Salmon Recapture Connecticut

by Stephen Fay

A decade-long struggle begins to pay off as Atlantic salmon return to a river they abandoned almost two hundred years ago

The mating, on November 11, 1976, of the Berkshire National Fish Hatchery's prize buck salmon with a bevy of fertile females was a painstakingly arranged consummation. Ten years of hard work, two devastating disappointments, and the expenditure of millions of federal and local dollars preceded the event.

This ichthyological equivalent of *The Matchmaker* featured a cast of remarkable characters and creatures and starred an 8½-pound, 33-inch male Atlantic salmon caught in a fish lift at Holyoke Water Power Company's dam on the Connecticut River. This particular buck was special because he was one of the few Atlantic salmon in the past 180 years to swim up New England's polluted and dammed Connecticut River in an attempt to spawn. He was additionally singular because he was born and bred in a hatchery.

Salmon had once been abundant in the Connecticut River, which courses through New Hampshire, Vermont, Massachusetts, and Connecticut. But the native population was reduced drastically when, in 1798, a 16-foot-high dam was erected at Turners Falls, Massachusetts. In the interests of hydropower, adult Atlantic salmon, returning from the high seas to the waters of their origin, were prevented from ascending the Connecticut River to their spawning streams in Vermont and New Hampshire. The stray salmon that traveled up the Connecticut vanished altogether by 1810 after other low-head dams went up on the river and its tributaries.

Biologists hope to restore this once abundant fish to the misused river through the eugenics experiment for which the prized salmon described above was reared.

Born in one of the Department of the Interior's New England fish hatcheries and raised in a large cement pool, the big buck and thousands of other salmon were the offspring of wild Atlantic salmon that continue to thrive in the Saint Lawrence River, Maine's Penobscot River, or other northeastern rivers. At the age of two, when he was a six- or seven-inch smolt, the salmon was released with thousands of other males and females into one of the free-flowing tributaries of the Connecticut River. Biologists were simply playing the odds: out of all the hundreds of thousands of smolts dumped into the river maybe, just maybe, a sufficient number would return to spawn an indigenous strain of Connecticut River Atlantic salmon.

An Atlantic salmon attempts to leap a cascade of water on its way upriver to spawn. Dams constructed without fish ladders are insurmountable obstacles for the most determined salmon.

Tom Blagden, Jr.

One-year-old smolts, right, are raised in a number of National Fish Hatcheries in the northeast. They are kept in covered brooding pools, such as the one in Maine pictured below, until they are at least two years old. Hundreds of thousands of such artificially reared young salmon have been released in the Connecticut River and its tributaries in the hope that some will return to spawn when sexually mature adults. In the Southwest Miramichi River, New Brunswick, Canada, bottom, right, a female Atlantic salmon heavy with eggs scrapes a nest in the river bottom. A male swims nearby, ready to fertilize the eggs with his milt as she releases them.

Russ Kinne, Photo Researchers



James Dickinson, Photo Researchers





Tom Blagden, Jr.

The undertaking appeared to be worthwhile and effective last summer, when a total of eighty-one returnees were caught in the river and removed for breeding, but in its early years the salmon restoration effort was marked by frustration and calamity.

A year before the big buck was caught, an equally promising Atlantic salmon male was captured at the Holyoke dam. On June 23, 1975, the first hatchery-bred Atlantic salmon was captured in the river after returning from its feeding period at sea. This news brought a jubilant response: environmentalists, sport fishermen, and people who had been hoping all along that Rachel Carson's anticipations would not come to pass joined in hailing the return of the Atlantic salmon.

It was a richly significant first—the first Atlantic salmon to warrant the belief that the effects of pollution and industrialization of the Connecticut River could be re-

versed. A long-dormant mechanism was thrown into action as fish biologists throughout the northeast learned the glad tidings. A team from the federal fish hatchery in the Berkshire County town of New Marlborough, Massachusetts, was dispatched to pick up the salmon and transport it to the hatchery. It would be kept there until ready for mating in late October.

Roger I. Lanse, coordinator of the Connecticut River Anadromous Fish Restoration Program, was particularly pleased. An employee of the Department of the Interior, Lanse had worked since 1967 with environmental agencies in New Hampshire, Vermont, Massachusetts, and Connecticut in an effort to replenish the river with shad and Atlantic salmon. He, along with a gaggle of federal Fish and Wildlife Service agents and conservationists, paid visits and homage to the New Marlborough hatchery's new tenant. Plans were made to ship four or five female Atlantic salmon from Maine's Penobscot River to the hatchery for breeding. The females would be wild fish, taken from their native river in autumn after they had returned from the ocean to spawn.

But on Monday, September 29, 1975, the plans and hopes came to an abrupt halt. The valued male salmon, which had been moved from a large natural pond at the hatchery to a small cement tank 100 yards closer to the hatchery laboratory, died, biologists believe, as a result of his instincts. His shallow tank had been covered with a light mesh net staked out around the perimeter of the pool. Fresh water cascading into the pool from a water pipe probably bore too great a resemblance to the waterfalls this active salmon had leaped up and over during his journey up the Connecticut. He leaped at the challenging cascade, hit the lip of the covered pool, slithered under the net, and landed on the soft grass beyond the pool, where he quickly died.

William V. Wallentine, project leader at the hatchery, found the dead salmon the next morning. A big down-easter who always spoke with affection for the frisky salmon that had put his hatchery on the environmental map, Wallentine sat



Dick Smith



Dick Smith



down and cried. A few days later he said he would be ready when the next salmon was caught: he would cover the holding pool with chicken wire and stake it down inside the pool. Nine months elapsed before he had the opportunity to demonstrate his redoubled vigilance.

In March 1976, Lanse and Wallentine spent a chilly week in the hatchery laboratory, branding smolts and discussing the future of the restoration program. More returnees were needed to justify the program and provide biologists with salmon possessing the migratory instincts that, once passed on to subsequent generations, would insure

The Connecticut River, near Ryegate, Vermont. Until the late eighteenth century, the river was the scene of major salmon spawning runs. Dams and pollution eliminated the salmon.

The headwaters of the Connecticut River rise in northern New Hampshire. The river courses southward through Vermont, Massachusetts, and Connecticut on its way to the Atlantic Ocean.



an enduring population of Connecticut River Atlantic salmon.

But the two of them knew that fortune, more than planning, would determine the outcome of the effort because so little is known of the migratory and spawning instincts of salmon. There is general agreement that smolts, whether spawned in a river or deposited there from hatcheries, gain an olfactory impress of the smell of their particular river. That smell is not forgotten after they swim downstream to the salt waters where they will feed for the next two or three years. Before venturing forth from the river to feed on various crustaceans in the ocean, the salmon dally for several weeks in the estuarine waters at the river's mouth. This may provide a period of acclimation so that the transition from freshwater to a sea environment is not too abrupt. But how salmon manage to find their way over thousands of miles of ocean to their feeding grounds and back again to their native fresh waters is not known. Lanse puts some stock in the theory that the earth's magnetic fields help the salmon navigate.

Salmon navigate not only accurately but also according to a precise timetable. When it is time to spawn, their built-in sense of time alerts them to head back from distant feeding grounds to the rivers of their origin. Atlantic salmon make runs upstream twice a year, in the late spring and early fall. It was during the spring 1976 spawning run that Wallentine and the other regional participants in the Atlantic salmon restoration program got their second big chance. A hefty female salmon was caught in the Holyoke Water Power Company's fish lift on June 11, 1976. The machinery that had been put into motion a year earlier, when the first returnee showed up in the fish lift, was swiftly set in motion again.

About everything that could go wrong went wrong with the retrieval of this 40-inch, 23-pound hen. The truck dispatched from the New Marlborough hatchery to Holyoke to fetch the new specimen was twelve years old and feeble. The salmon was taken, via net, from the lift and placed in a special tank mounted on the back of the hatchery's 1964 pickup. Then, technicians Donald Williams and David P. Curtin started the ninety-minute ride back to the hatchery. A few minutes later, as they cruised down the Massachusetts Turnpike, the truck—with the aquatic equivalent of the $6 Million Man in back—developed engine trouble and the two anxious men found themselves crawling along the highway at 25 mph. The return to the hatchery

took them almost four hours—three times longer than normal.

A couple of days later the female salmon became ill. Curtin spent a day and a night in the pond with her, helping her stay afloat, righting her when she flopped on her side. No one knew what the problem was and hatchery personnel despaired. On June 17, 1976, five days after she had been removed from the Holyoke lift, the female died. The 15,000 eggs in her large belly would never be fertilized, a serious blow for the program. Three months later, the Fish and Wildlife Service disclosed that a forensic laboratory had determined that the hen died from a pneumonialike infection; concentrations of bacteria had been found in her tissues. The trauma of the long ride to the hatchery had apparently lowered the hen's resistance.

Another Atlantic salmon dead, another potential spawning run gone, and little chance of a new salmon appearing in the river that year. But that little chance was enough to justify operation of the fish lift until December. Built in 1975, the lift is owned and operated by the power company and serves to lift American shad and Atlantic salmon over the Holyoke dam. Although the lift is usually shut down in November, the company's concern and cooperation brought about an extension of that date.

No one thought it would do any good. Don Williams, after thirty-two years with the Fish and Wildlife Service, had retired, and Bill Wallentine was on vacation. So Dave Curtin was all alone on the afternoon of October 25, 1976, when Atlantic salmon number 3, a male, swam into the fish lift at Holyoke.

Everything went perfectly this time. Curtin raced out to Holyoke in the hatchery's brand new truck and picked up the salmon. On his return to the hatchery, he prudently mixed small amounts of the holding pool's cool water into the truck's portable tank to acclimate the fish to his new environment. The salmon was carried in a net down to a long, deep, narrow cement pool and plans were immediately made for mating the new male.

Since salmon spawn in the fall, as well as in the spring, there was every reason to believe that this buck was about ready to fertilize eggs. When a test of his milt, or sperm, showed that it was motile, four Penobscot females were shipped from Maine's Craig Brook hatchery. Eggs stripped from the four hens were placed in a basin and the male was lifted from his tank and held over them. He was squeezed gently around the abdomen until a stream of his milt flowed onto the 30,000 eggs. The fertilized eggs were then removed to the Pittsford, Vermont, hatchery where the most sophisticated incubation equipment in the northeast is located.

Since that first big break in November of 1976, when the third of the three salmon caught in the Holyoke lift lived long enough to fertilize eggs, the Atlantic salmon restoration effort has made more progress and encountered more problems. On June 15, 1977, two years after she had been released as a smolt into a tributary of the Connecticut, a 29-inch, 6½-pound female salmon was snagged by the hook of a fisherman who was after blueback herring in Connecticut's Salmon River. The Salmon River is a tributary of the Connecticut River, which joins it twenty miles north of Long Island Sound. This female bore a numbered tag, affixed when she was a smolt to identify her as hatchery-raised stock. Spotting the tag, the fisherman kept the salmon in a pool until the retrieval team from the New Marlborough hatchery arrived on the scene.

This female and a male captured in the Holyoke fish lift in July lived to become the principals in a historic, if involuntary, mating at the hatchery November 8, 1977. After the female's approximately 8,000 eggs were expressed from her abdomen into a plastic basin, the male was lifted over the basin and gently squeezed until his milt flowed over the eggs.

"This is pure Connecticut River stock," said William Purcell, Wallentine's successor as hatchery manager.

The fingerlings produced by this union are being raised at the hatchery until it is time to release them into the Connecticut River in 1979 or 1980. Because both parents were Connecticut River returnees, participants in the restoration effort are hopeful that these little salmon will bear a particularly strong inclination to return to their natal river after their feeding stint off the coasts of Greenland or Labrador.

The 1978 restoration effort was attended by the greatest success and the worst defeats. A total of eighty-one Atlantic salmon were captured in the Holyoke lift and the Rainbow Dam fish ladder on the Farmington River north of Hartford. (The Farmington is also a tributary of the Connecticut.) But of those eighty-one, all of which were successfully transported to the New Marlborough hatchery, only two were still alive as of November 1, 1978. Furunculosis, a bacteriological infection that is as deadly to salmon and other fish as plague once was to humans, turned a triumphant year into a dismal one.

"It's totally depressing," hatchery manager Purcell said as the toll mounted last summer.

The disease, probably picked up in the Connecticut or one of its tributaries by the returnees as they swam upstream to spawn last spring, is difficult to treat because the antibiotics with which biologists normally respond have to be injected into the fish with hypodermic needles. Antibiotics cannot be introduced via fish feed because salmon and other androgenous fish do not eat during the months-long spawning period. The process of catching and injecting the already weakened salmon caused deadly trauma.

The encouraging aspect of this year's results is the remarkably high number of Atlantic salmon that have returned to the rivers of their artificially induced origins. There is no reason to think the return rate will be any less exceptional next year and the year after. A few mass breedings of Connecticut River returnees over the next few autumns could restore a population that will renew itself naturally, without the benign interference of humans whose ancestors originally caused so much trouble for this most handsome of creatures. □

Ronald Thompson; Bruce Coleman

The Onslaught Against Hawaii's Tree Snails

by Alan D. Hart

Threatened by everything from humans to carnivorous relatives, these gems of the forest are rapidly being exterminated

Had Charles Darwin visited Hawaii, he would have found in the archipelago another natural laboratory that vividly demonstrated his theory of evolution. The islands are the most geographically isolated in the world, separated from the nearest continent or large island group by more than 2,200 miles of Pacific Ocean. Isolation, time, and habitat diversity have produced a most distinctive land biota. More than 97 percent of Hawaii's native flowering plants, nonmigratory land birds, insects, and land snails occur naturally nowhere else on earth.

For the past six years, I have studied a remarkable group of Hawaiian tree snails that evolved on the island of Oahu. They belong to the genus *Achatinella* ("little agate"), and their forty-one named species have been called "gems of the forest." Now, more than half of these once abundant species may be extinct, and the rest are increasingly rare and endangered.

Their shells come in an amazing assortment of colors—various shades of red, orange, yellow, brown, green, gray, blue, black, and white—and countless patterns, many quite spectacular. Evolutionist John T. Gulick, the son of early New England missionaries, who grew up in Hawaii during the nineteenth century, said of the snails, "We have right here on Oahu, the most beautiful, varied and highly developed land shells of the world." (Today, more than 20,000 species of land snails are known.)

Most *Achatinella* tree snails live at elevations from 1,000 to 3,700 feet in the native and introduced forests of the Koolau and Waianae mountain ranges. They are nocturnal and generally inhabit low shrubs and trees. During the day, they rest alone or in small clusters sealed to branches, trunks, or the undersides of leaves. At night, they graze leaf and bark surfaces for microscopic algae, fungi, liverworts, and detritus. They have rasping teeth specialized for that purpose and do not eat the tissues of their host plants.

The snails are hermaphroditic (bisexual) but not self-fertilizing. Mature individuals breed yearround and usually bear one live young at a time, complete with a tiny shell corresponding to the first few small whorls at the tip of the parent's shell. As the snail grows, secretions from the soft mantle of its body construct the lower, larger shell whorls. The maturation time or life span of any *Achatinella* species is not known.

These little snails are quite sedentary; one might live out its entire life in a single tree, especially if the tree is isolated. *Achatinella's* migration rates, from one area to another, are so slow that they would be measured in centuries rather than years, according to Yoshio Kondo, chief malacologist at Honolulu's Bishop Museum.

A species' distribution in a given area is unpredictable. Some snails prefer a certain type of tree, but they are not necessarily found on all trees of that species. I found thirteen *A. sowerbyana* in a small, half-dead hame tree with less than two dozen leaves, but none in more thickly foliated hame trees nearby.

Basic shell shapes of the various species are globular, conical, and ovate—denoting three subgenera, or groups of species with similar form. Adult shells range in length from half an inch to slightly over one inch, depending on the species. The number of shell whorls varies between five and seven throughout the genus, and the number can vary within a single species. A small "tooth," a distinctive character of the genus, protrudes from the twisted central column inside the shell. In some species the shells coil to the left or to the right; in other species the shells all coil the same way. Most species have smooth,

Endemic to Oahu's Koolau range, Achatinella lila *was thought to be extinct. Since 1973, several small colonies of this tree snail have been found, but the species remains endangered.*

William P. Mull

glossy shells, but a few have slightly sculptured shell surfaces.

The brilliant coloration is usually contained in the periostracum, a thin, pigmented cuticle forming the shell's outermost layer. The biological value of these colors is a puzzle. Malacologist Henry A. Pilsbry has suggested the opaque colors might be an adaptation to reflect bright Hawaiian sunlight. Despite their striking hues, these snails are easily overlooked, for they often conceal themselves in leaf curls or compact leaf clusters during the day. Also, their shell patterns tend to have a cryptic effect in the dappled light of the forest. On one field trip Pilsbry was embarrassed when two experienced local shell collectors told him that the best collecting was on trees he had already searched without finding a snail.

Achatinella's origin and development in Hawaii are extraordinary. The island of Oahu is in the southeastern part of the approximately 1,500-mile-long archipelago. On Oahu, two nearly parallel mountain ranges occupy opposite sides of the island, with the longer Koolau range in the east and the older Waianae range in the west. Oahu is actually the exposed tops of two enormous volcanoes that rise 18,000 feet from the ocean floor. About three million years ago, the Koolau and Waianae shield volcanoes merged to form the island. Since then, continuous stream erosion has carved their basalt domes into a complex of long, fingerlike ridges branching from jagged summit backbones. Amphitheater-headed valleys and ravines lie between, with countless spurs on their slopes. High cliffs and short buttress ridges, from two to four miles long, make up much of the Koolau's windward east slope. The Koolau's leeward west slope has numerous, gradually sloping ridges of varying length. The Waianae range's slope configuration is virtually opposite that of the Koolau. Oahu's highest point is 4,025-foot Mount Kaala in the Waianae range; most of the Koolau's 37-mile-long summit backbone is from 2,000 to 2,800 feet above sea level.

Many of the plants and animals that eventually colonized Oahu and the other volcanic Hawaiian Islands had physical features that facilitated long-distance dispersal, by wind, birds, or ocean currents, across the vast expanse of water that isolates Hawaii from the rest of the world.

We can only guess where *Achatinella*'s progenitor came from; the group has undergone such drastic changes over the ages that it has no close living relatives on continents bordering the Pacific basin. Against heavy odds, the snail's immigrant ancestor may have hitched a perilous ride to Hawaii aboard a bird straggler or drifting log. This snail likely arrived and established itself on the island of Maui or Molokai. Finding an ideal climate, unlimited



Achatinella fulgens, *another rare species, rests on the trunk of a guava tree. Hawaiian tree snails seal themselves to bark and leaf surfaces with a mucous membrane.*

John F. Walters

food, few predators, and little competition, it proliferated. Its progeny adaptively shifted to arboreal habits and gave rise to four modern genera. *Partulina* and two offshoots, *Newcombia* and *Perdicella*, evolved on Maui and Molokai and, eventually, *Partulina* snails spread to the islands of Lanai, Oahu, and Hawaii.

On Oahu, the *Partulina* line exploited a variety of ecological zones —from sea level to high mountain tops—to speciate, prosper, and become *Achatinella*. At least two of these early species apparently migrated from the Koolau range, scene of *Achatinella*'s richest development, to the Waianae range and evolved into several more kinds. Presumably, by the time the first humans arrived, Oahu's forests were bejeweled with tree snails in an unending rainbow of color patterns.

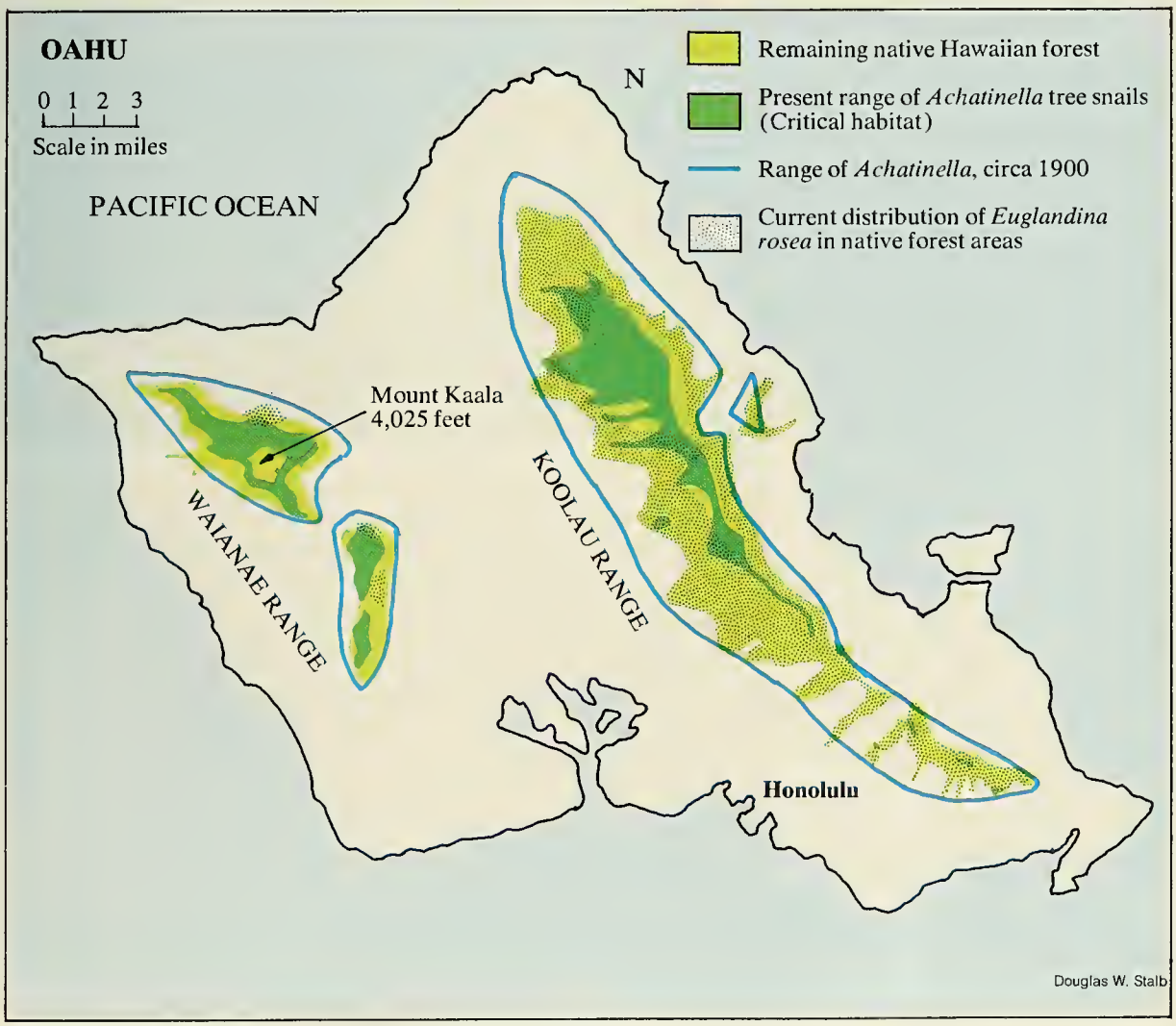
Polynesian immigrants from the Marquesas and Society Islands to the south were the first people to conquer the formidable oceanic barrier and reach Hawaii, in the first millennium A.D. They became familiar with the plants and animals in their new environment, including the tree snails.

The old Hawaiians strung "little agates" into anklets, bracelets, and necklaces called leis. European scientists' first contact with the snails was through such leis. During a visit to Oahu in 1786, a British captain, George Dixon, acquired a lei of *A. apexfulva* shells from the natives in exchange for a nail. In Europe, the shells created an immediate sensation. Dixon's lei was broken up, and each shell was sold for upwards of forty dollars.

Based on erroneous information given to Dixon, scientists first classified *Achatinella* as a freshwater snail. In those early decades of European contact, little collecting was done by trained naturalists. What few shell specimens reached Europe were brought by adventurous navigators with vague collecting data: "Oahu" or "Sandwich Islands."

Because conchologists usually described snail species by their shell characteristics, mere color

Achatinella*'s habitat and range have been greatly reduced within the span of a human lifetime. Note the close relationship between the distribution of* Euglandina *and the disappearance of* Achatinella.



forms of a particular snail were classified as "new species." This practice soon led to a taxonomic nightmare. When English naturalist William Swainson erected the genus *Achatinella* in 1828, seven species were known. As Oahu's wilderness was explored, myriad new forms of snails were discovered. By 1888, the genus had ballooned to 227 described species, with about 900 varieties—all from a land area equal to that of modern Philadelphia or Detroit. And Oahu still had areas unexplored for tree snails. In 1914, Pilsbry and C. M. Cooke, a local land snail expert, published a monograph on Hawaiian tree snails. They reduced the genus to 43 species, but later two more species were dropped, leaving the group with its present total of 41. Still, the debate continues, and some modern biologists now estimate there may only be 12 good species of *Achatinella*.

The fascinating variability of *Achatinella*'s shells provides a classic demonstration of the process of organic evolution. The first person to recognize the biological significance of this variability was John Gulick. More than a decade before Darwin shook the world with his revolutionary ideas, teen-ager Gulick was collecting *Achatinella* in Oahu's mountains. He was intrigued by the apparent relationship between the tree snails' shell variations and the island's terrain. Gulick discovered that the shells in a single valley displayed color forms unique to that valley—or a part of it—and were unlike those in adjacent valleys. Intermediate forms were often found on ridges separating the valleys. Furthermore, he noted that most species occupied small geographical territories and that many color forms were restricted to colonies measuring only a few square yards. Gulick could tell which ridge or valley a shell came from by noting its shape, color, and pattern.

Gulick theorized that by furnishing geographical barriers that isolated tree snail populations, Oahu's rugged topography was largely responsible for *Achatinella*'s diversity. In 1872, he traveled to London with part of his Hawaiian land-shell collection and discussed it at length with Darwin, Alfred Russell Wallace, and others. Gulick also presented a paper on *Achatinella* snails before the Linnaean Society.

By the turn of the century, Gulick was recognized as a prominent post-Darwinian evolutionist. Pilsbry and Cooke acknowledged Gulick's work in the preface to their tree snail monograph: "The Achatinellidae hold an important place in general biological literature for the reason that a contribution of the first importance to the doctrine of evolution arose from a study of these snails."

Since Gulick's time, several detailed field studies have shown *Achatinella*'s incredible localization. In the 1890s, Cooke found twenty-five different color varieties of *A. bellula multizonata* within the six-mile length of the Nuuanu valley behind Honolulu. Later, malacologist D'alte Welch discovered that *A. apexfulva* might have as many as five subspecies on one Koolau ridge, phasing from one to another as altitude increased along the ridge. A striking example of localization within a species is shown by *A. mustelina*, endemic to the Waianae mountains. According to Welch, *A. mustelina* has developed twenty-six subspecies and sixty distinct microgeographical color races within its twenty-mile-long range. The most localized subspecies of the genus was probably *A. lehuiensis meineckei*, now extinct, whose total known range was one ohia tree in the Waianae mountains!

The beautiful snails caught the public's interest as well, and tree snail shell collecting became the vogue in Hawaii. In fact, the alluring charm of *Achatinella*'s shells caused a "land shell fever" on Oahu from 1850 to 1900. During that period, many species of tree snails were extremely abundant in areas above 1,000 feet. In 1886, D. D. Baldwin, a local land snail authority, and a friend easily collected 3,000 shells in the Koolau range within a few days. Since no two shells were exactly alike, people collected many. Over the years, a multitude of people collected hundreds of thousands, perhaps millions, of living snails for their shells. Several private collections approached 100,000 specimens each. As a rule, collectors killed the animals by drowning them.

For many people, collecting became an obsession. Oliver Emerson, one of Gulick's boyhood friends, recalled "the rarest days of all . . . those we spent hunting for



A carnivorous snail, Euglandina rosea, *feeds on a native* Achatinella sowerbyana. *These predators, introduced from Florida, are partly responsible for the recent decline of many Hawaiian land snails.*

Robert J. Western



tree snails. . . . I still feel the exhilaration of those excursions, the zest of coming upon a hidden surprise of nature, some fine specimens of those beautiful shells. . . ."

In accessible places, the snails were undoubtedly decimated by overcollecting. But few people did extensive collecting in both mountain ranges. Former collectors George Arnemann, William Meinecke, and Herman Lemke, Jr., have told me that many species were still very plentiful in the 1930s.

George Arnemann remembers weekends when a gang of enthusiasts would grab bagfuls of jars, pile into an old Model T, and drive up through muddy sugarcane fields to tree snail country. Arriving there, they scattered for the day to search for colorful snails. The real devotee spent the whole weekend gleaning the trees for their precious treasures, eventually exploring every ridge, valley, and ravine to get as many varieties as possible.

Sometimes rivalries developed between collectors. If someone discovered an exclusive color race in a new locality, another collector might beseech him for the snail's whereabouts. Occasionally, the discoverer would give the inquirer the wrong locale and send him on a wild snail chase.

Few old-timers kept accurate field notes, essential to the serious study of *Achatinella*. They usually collected snails from a variety of locations and then labeled them all as coming from one general place. After 1932, men like William Meinecke began plotting precise collecting sites on newly available topographic maps.

Among the most sought-after species was *A. rosea* of the Koolau range. Pilsbry called it "one of the most exquisite of land shells" because of its delicate coloration. This species was typically glassy milk white, with pinkish tints deepening to rose around the aperture. Other varieties came in salmon, dark red, and pale yellowish green with pink bands. Unfortunately for



Accompanied by its offspring, an Achatinella sowerbyana *grazes the surface of a leaf for algae and fungi. The hermaphroditic snails have a low reproductive rate, usually giving birth to one live young at a time.*

William P. Mull



collectors, the pink and red hues faded to a fawn brown with age.

As a teen-ager in the 1930s, Lemke once found a large, solid red *A. rosea,* the prize of prizes. After exhibiting the shell publicly, he carefully wrapped it and other fresh *A. rosea* shells in cotton and stored them away, hoping to prevent them from fading. He was somewhat successful; when I saw them recently, they still retained a bright pink color. The last living *A. rosea* were collected in the early 1960s.

The days of *Achatinella*'s widespread abundance are gone. Today, live tree snails are rare in most places on Oahu, a change from conditions only a few decades ago. Illustrating the recent decline of *Achatinella,* Kondo compiled a survey of the genus in 1970, based on his field experiences up to the early 1960s and on all available information. He listed fourteen species as extinct, twenty-five as rare and endangered, and two as common.

Since 1972, I have been doing a careful island-wide survey, with help from other local naturalists, to determine *Achatinella*'s current status. My tentative findings show an alarming twenty-one species as possibly extinct, and twenty as endangered. These results indicate an extinction rate of more than 50 percent in the past two centuries. In the case of two extant species, *A. turgida* and *A. bulimoides,* only one living animal of each was located and I have not found either species alive in the wild since. A third species, *A. lorata,* may have suffered a similar fate.

In 1961, Kondo published an account naming three *Achatinella* species, including *A. lorata,* that could easily be seen on Mount Tantalus behind Honolulu. By contrast, twelve years later I was lucky to find what might have been the last four living individuals of *A. lorata* on a hame tree; I have not found any living individuals of the other two species.

Achatinella owes its present rarity primarily to human alteration and destruction of Oahu's native ecosystems, especially since statehood eighteen years ago. This famous island has suffered sorely from human immigrants who came to enjoy it. The cost: a substantial part of its irreplaceable natural heritage. About 85 percent of the native forests that once covered most of Oahu have been destroyed, and the remaining 15 percent are biologically polluted by alien plants and animals introduced by humans. Six kinds of endemic forest birds are known to have become extinct on Oahu in the past two hundred years.

The problem began more than a thousand years ago with colonizing Polynesians, who introduced pigs, dogs, rats, chickens, and certain plants for food and cultural needs, among them taro, yams, bananas, and the coconut palm. To cultivate those plants, these immigrants destroyed or altered many native lowland ecosystems. But since they lived mainly in coastal regions, they had little impact on the mountains and Hawaii's higher forests remained intact.

The destruction of Oahu's wilderness increased after 1778, the year British explorer James Cook discovered the Hawaiian Islands for the Western world. In 1791, Capt. Charles Vancouver brought cattle, sheep, goats, pigs, and a number of foreign plants to Oahu.

Endemic Hawaiian ecosystems evolved for millions of years in the absence of four-legged herbivores and developed no effective defense mechanisms against them, such as poisons, thorns, and deep roots. Cattle were destructive and killed many trees by trampling vulnerable root systems. Regeneration was prevented when seedlings were trampled, uprooted, and eaten. Also, Hawaiian plants and animals were naturally less competitive than their continental relatives and were ill-equipped to resist the man-assisted invaders. With the sandalwood trade, ranching, and continental-style commercial agriculture, a high percentage of Oahu's woodlands below 1,000 feet was deforested, and most of the tree snails in those forests vanished with them.

By the end of the nineteenth century, forest destruction was so widespread that a critical need arose for reforestation to conserve water and prevent soil erosion. Fast-growing exotics, such as Australian eucalyptus, ironwood, and Norfolk Island pine, were imported and planted instead of native trees. Less than half of *Achatinella*'s species have adapted to introduced plants and trees. Other types of vegetation were deliberately or accidentally introduced into low wooded ravines and higher forests, further diluting the snails' food supply.

Forest fires have denuded the lower slopes of many ridges and ravines and continue to threaten remaining native forests. Since 1970, Oahu has had at least five large forest fires in or near endemic tree snail habitat. The armed forces use vast areas of forestlands in both mountain ranges for training exercises and artillery practice. In May 1975, I watched native forest burn for several days above a major firing range in the Waianae mountains.

Introduced rodents are another major problem for the snails. Tree-climbing rats can dislodge native tree snails, bite open their shells, and extract the insides. Baldwin found hundreds of broken tree snail shells piled around the openings of rat and mouse dens in the 1880s. Recently, I found a dozen shells of fresh rat-killed *A. mustelina* under one tree.

An ill-omened event in 1955 sealed the fate of many tree snails. Hawaii's Department of Agriculture was searching for a biological control agent to eliminate infestations of giant African snails (*Achatina fulica*), which were plaguing lowland homeowners. This plant-eating pest, whose adult shell can exceed five inches in length, was introduced to Oahu from Formosa in 1936 by a private individual who released the snails in a garden for aesthetic reasons. According to Henry van der Schalie, University of Michigan malacologist, a program was undertaken by agricultural *entomologists* to import and release a minimum of nineteen species of carnivorous snails from around the world to combat the African snails. The operation was done without adequate prior research to determine its prospective effectiveness and environmental impact—and against the recommendations of local malacologists.







William P. Mull



These four Achatinella lila *demonstrate color and pattern variations within a single, small colony. Before the taxonomic status of the genus was clarified, such variations were often classified as separate species. Shell collectors have prized each variation; as a result, local populations have been wiped out. Introduced tree-climbing rats and predatory snails have also severely depredated this and other* Achatinella *species. Another important factor leading to the decline and extinction of tree snails has been forest clearing.*

The most important carnivorous snail released on Oahu was *Euglandina rosea*, a large voracious species also known as the cannibal snail. I learned the reason for *Euglandina*'s nickname after collecting two live specimens and keeping them together in the same container overnight. The next morning I had one well-fed *Euglandina* and one fresh empty shell. In its native Florida, *Euglandina* preys upon the attractive *Liguus* tree snails. Cannibal snails are at home on the ground or in trees and occupy a variety of habitats. After its initial release on Oahu, the cannibal snail's population mushroomed. Migrating out of the low, drier areas, the snails headed for the mountain forests, where they continue to feed on defenseless native land snails. To quote Van der Schalie, "the establishment of *Euglandina* now appears a most serious error and this introduction may well prove ruinous to the native endemic snails in the mountain regions." The evidence I have accumulated during my survey generally supports Van der Schalie's contentions. Nearly a dozen species of *Achatinella*, common a few decades ago, have disappeared since *Euglandina* invaded their former ranges. Populations of other *Achatinella* species have been seriously decimated by this deadly molluscan menace, particularly in the southern half of the Koolau range. In regions where *Euglandina* is long established, living *Achatinella* snails usually are very rare. Veteran Hawaii mountaineer Dick Davis, a frequent hiking partner, recalls seeing a prolific colony of *A. taeniolata* in the southern Koolau mountains during the mid-1960s. "There were bushels of them all over the place, especially on the small olomea trees," he told me casually. I went to the same place a decade later and found numerous *A. taeniolata* shells, mingled with *Euglandina* shells, rotting on the ground. Today, *A. taeniolata* is extremely rare and close to extinction. The giant African snail, however, can still be found in the lowlands.

Searching for live *Achatinella* these days requires plenty of patience, determination, and luck. Many of my quests have ended in failure. One day I hiked fourteen miles without seeing an *Achatinella*, although I knew that four species once occurred along the route. Hiking in Oahu's mountains can be difficult and often dangerous. Rescues of lost, injured, or stranded hikers are common, and hiking-related deaths are high. The Waianae range is notorious for its knife-edge ridges; its precipitous slopes fall away in 1,500-foot—or more—drop-offs, and the crumbly volcanic rock and smooth, weathered boulders make treacherous footing.

Finding a rare *Achatinella* species and knowing it still exists is my reward for the hardships of fieldwork. I have experienced the thrill of tentatively rediscovering three *Achatinella* species believed to be extinct on the basis of Kondo's previous survey. Among them is *A. lila*, whose green varieties are regarded as Oahu's most beautiful living forest gems.

Public awareness of *Achatinella*'s plight is scant. The majority of Oahu's cosmopolitan population lives in lowland areas and is more familiar with the human-introduced biota that dominates that region. The word "snail" would suggest giant African snails to most Oahuans. Rallying people to save a group of snails that have little, if any, contact with humans is all but impossible. When the average person sees a live *Achatinella*, he collects it. Hawaiian tree snails are seldom mentioned in popular literature, and the only local exhibits of their shells are in several missionary house museums and periodic displays at Bishop Museum.

Most Hawaiian schools use North American biology textbooks and place little emphasis on Hawaii's natural history. A few enlightened teachers and outside lecturers help fill this void. I have noticed that most local young people respond with amazement, enthusiasm, and new-found pride when they learn about their singular Hawaiian natural heritage. Fortunately, the University of Hawaii offers popular courses in Hawaiian natural history, and various conservation groups conduct field trips emphasizing the native environment.

Forest management on Oahu is dictated by a multiple-use concept, many people using forestlands for different purposes. However, this policy officially sanctions the existence of feral animals in native forest areas for the benefit of Oahu's small number (about 0.7 percent) of local hunters. The presence of wild pigs, for example, is hardly compatible with the health and welfare of remaining native forests.

Oahu's endemic tree snails and their habitat have fallen victim to human ignorance and neglect. All that remains are scattered fragments of once delicately balanced ecosystems. *Achatinella*'s accelerating decline indicates these snails are generally unable to adjust to the continuing alteration of their fragile insular environment brought about by modern civilization. The various factors responsible for *Achatinella*'s deterioration are still present, and as Oahu's human population increases, new threats may arise.

Time seems to be running out for many *Achatinella* species when we still have much to learn about them. The genus needs taxonomic revision and many aspects of its biology and ecology are unknown. At the moment, no in-depth malacological fieldwork is under way on Oahu to tackle the immense problems facing the group.

These animals have greatly advanced our knowledge of organic evolution on oceanic islands. Yet, we are letting this important natural and scientific resource slip irretrievably through our fingers. The presence of *Achatinella* snails adds priceless beauty, interest, and diversity to Oahu's native forests. No effort should be spared to save what is left of these rapidly dwindling Hawaiian legacies. □

The eyes of Achatinella apexfulva *are located at the tips of the two upper tentacles. The two lower tentacles contain sensory organs that the snail uses to feel its way about. The snails travel about three inches a minute.*

William P. Mull



Hard Times among the Neanderthals

Text and photographs by Erik Trinkaus

Although life was difficult, these prehistoric people may not have been as exclusively brutish as usually supposed

Throughout the century that followed the discovery in 1856 of the first recognized human fossil remains in the Neander Valley (*Neanderthal* in German) near Düsseldorf, Germany, the field of human paleontology has been beset with controversies. This has been especially true of interpretations of the Neanderthals, those frequently maligned people who occupied Europe and the Near East from about 100,000 years ago until the appearance of anatomically modern humans about 35,000 years ago.

During the last two decades, however, a number of fossil discoveries, new analyses of previously known remains, and more sophisticated models for interpreting subtle anatomical differences have led to a reevaluation of the Neanderthals and their place in human evolution.

This recent work has shown that the often quoted reconstruction of the Neanderthals as semierect, lumbering caricatures of humanity is inaccurate. It was based on faulty anatomical interpretations that were reinforced by the intellectual biases of the turn of the century. Detailed comparisons of Neanderthal skeletal remains with those of modern humans have shown that there is nothing in Neanderthal anatomy that conclusively indicates locomotor, manipulative, intellectual, or linguistic abilities inferior to those of modern humans. Neanderthals have therefore been added to the same species as ourselves—*Homo sapiens*—although they are usually placed in their own subspecies, *Homo sapiens neanderthalensis*.

Despite these revisions, it is apparent that there are significant anatomical differences between the Neanderthals and present-day humans. If we are to understand the Neanderthals, we must formulate hypotheses as to why they evolved from earlier humans about 100,000 years ago in Europe and the Near East, and why they were suddenly replaced about 35,000 years ago by peoples largely indistinguishable from ourselves. We must determine, therefore, the behavioral significance of the anatomical differences between the Neanderthals and other human groups, since it is patterns of successful behavior that dictate the direction of natural selection for a species.

In the past, behavioral reconstructions of the Neanderthals and other prehistoric humans have been based largely on archeological data. Research has now reached the stage at which behavioral interpretations from the archeological record can be significantly supplemented by analyses of the fossils themselves. These analyses promise to tell us a considerable amount about the ways of the Neanderthals and may eventually help us to determine their evolutionary fate.

One of the most characteristic features of the Neanderthals is the exaggerated massiveness of their trunk and limb bones. All of the preserved bones suggest a strength seldom attained by modern humans. Furthermore, not only is this robustness present among the adult males, as one might expect, but it is also evident in the adult females, adolescents, and even children. The bones themselves reflect this hardiness in several ways.

First, the muscle and ligament attachment areas are consistently enlarged and strongly marked. This implies large, highly developed muscles and ligaments capable of generating and sustaining great mechanical stress. Secondly, since the skeleton must be capable of supporting these levels of stress, which are frequently several times as great as body weight, the enlarged attachments for muscles and ligaments are associated with arm and leg bone shafts that have been reinforced. The shafts of all of the arm and leg bones are modified tubular structures that have to absorb stress from bending and twisting without fracturing. When the habitual load on a bone increases, the bone responds by laying down more bone in those areas under the greatest stress.

In addition, musculature and body momentum generate large forces across the joints. The cartilage, which covers joint surfaces, can be relatively easily overworked to the point where it degenerates, as is indicated by the prevalence of arthritis in joints subjected to significant wear and tear over the years. When the surface area of a joint is increased, the force per unit area of cartilage is reduced, decreasing the pressure on the cartilage.

Most of the robustness of Neanderthal arm bones is seen in muscle and ligament attachments. All of the muscles that go from the trunk or the shoulder blade to the upper end of the arm show massive development. This applies in particular to the muscles responsible for powerful downward movements of

This fossil is part of the Neanderthal skeleton known as Shanidar 1, unearthed in a cave in northern Iraq. The outside of the left eye socket of the skull is flattened instead of rounded, the result of a serious blow.





Diagonal lines on these two arm bones from Shanidar 1 are healed fractures. The bone on the right is normal. That on the left is atrophied and has a pathological tip, caused by either amputation or an improperly healed elbow fracture.

the arm and, to a lesser extent, to muscles that stabilize the shoulder during vigorous movements.

Virtually every major muscle or ligament attachment on the hand bones is clearly marked by a large roughened area or a crest, especially the muscles used in grasping objects. In fact, Neanderthal hand bones frequently have clear bony crests, where on modern human ones it is barely possible to discern the attachment of the muscle on the dried bone.

In addition, the flattened areas on the ends of the fingers, which provide support for the nail and the pulp of the finger tip, are enormous among the Neanderthals. These areas on the thumb and the index and middle fingers are usually two to three times as large as those of similarly sized modern human hands. The overall impression is one of arms to rival those of the mightiest blacksmith.

Neanderthal legs are equally massive; their strength is best illustrated in the development of the shafts of the leg bones. Modern human thigh and shin bones possess characteristic shaft shapes adapted to the habitual levels and directions of the stresses acting upon them. The shaft shapes of the Neanderthals are similar to those in modern humans, but the cross-sectional areas of the shafts are much greater. This implies significantly higher levels of stress.

Further evidence of the massiveness of Neanderthal lower limbs is provided by the dimensions of their knee and ankle joints. All of these are larger than in modern humans, especially with respect to the overall lengths of the bones.

The development of their limb bones suggests that the Neanderthals frequently generated high levels of mechanical stress in their limbs. Since most mechanical stress in the body is produced by body momentum and muscular contraction, it appears that the Neanderthals led extremely active lives. It is hard to conceive of what could have required such exertion, especially since the maintenance of vigorous muscular activity would have required considerable expenditure of energy. That level of energy expenditure would undoubtedly have been maladaptive had it not been necessary for survival.

The available evidence from the archeological material associated with the Neanderthals is equivocal on this matter. Most of the archeological evidence at Middle Paleolithic sites concerns stone tool technology and hunting activities. After relatively little change in technology

during the Middle Paleolithic (from about 100,000 years to 35,000 years before the present), the advent of the Upper Paleolithic appears to have brought significant technological advances. This transition about 35,000 years ago is approximately coincident with the replacement of the Neanderthals by the earliest anatomically modern humans. However, the evidence for a significant change in hunting patterns is not evident in the animal remains left behind. Yet even if a correlation between the robustness of body build and the level of hunting efficiency could be demonstrated, it would only explain the ruggedness of the Neanderthal males. Since hunting is exclusively or at least predominantly a male activity among humans, and since Neanderthal females were in all respects as strongly built as the males, an alternative explanation is required for the females.

Some insight into why the Neanderthals consistently possessed such massiveness is provided by a series of partial skeletons of Neanderthals from the Shanidar Cave in northern Iraq. These fossils were excavated between 1953 and 1960 by anthropologist Ralph Solecki of Columbia University and have been studied principally by T. Dale Stewart, an anthropologist at the Smithsonian Institution, and myself. The most remarkable aspect of these skeletons is the number of healed injuries they contain. Four of the six reasonably complete adult skeletons show evidence of trauma during life.

The identification of traumatic injury in human fossil remains has plagued paleontologists for years. There has been a tendency to consider any form of damage to a fossil as conclusive evidence of prehistoric violence between humans if it resembles the breakage patterns caused by a direct blow with a heavy object. Hence a jaw with the teeth pushed in or a skull with a depressed fracture of the vault would be construed to indicate blows to the head.

The central problem with these interpretations is that they ignore the possibility of damage after death. Bone is relatively fragile, especially as compared with the rock and other sediment in which it is buried during fossilization. Therefore when several feet of sediment cause compression around fossil remains, the fossils will almost always break. In fact, among the innumerable cases of suggested violence between humans cited over the years, there are only a few exceptional examples that cannot be readily explained as the result of natural geologic forces acting after the death and burial of the individual.

One of these examples is the trauma on the left ninth rib of the skeleton of Shanidar 3, a partially healed wound inflicted by a sharp object. The implement cut obliquely across the top of the ninth rib and probably pierced the underlying lung. Shanidar 3 almost certainly suffered a collapsed left lung and died several days or weeks later, probably as a result of secondary complications. This is deduced from the presence of bony spurs and increased density of the bone around the cut.

The position of the wound on



The ankle and big toe of Shanidar 1's right foot show evidence of arthritis, which suggests an injury to those parts. The left foot is normal although incomplete.



The scar on the left ninth rib of Shanidar 3 is a partially healed wound inflicted by a sharp object. This wound is one of the few examples of trauma caused by violence.

the rib, the angle of the incision, and the cleanness of the cut make it highly unlikely that the injury was accidentally inflicted. In fact, the incision is almost exactly what would have resulted if Shanidar 3 had been stabbed in the side by a right-handed adversary in face-to-face conflict. This wound therefore provides conclusive evidence of violence between humans, the *only* evidence so far found of such violence among the Neanderthals.

In most cases, however, it is impossible to determine from fossilized remains the cause of an individual's death. The instances that can be positively identified as prehistoric traumatic injury are those in which the injury was inflicted prior to death and some healing took place. Shortly after an injury to bone, whether a cut or a fracture, the damaged bone tissue is resorbed by the body and new bone tissue is laid down around the injured area. As long as irritation persists, new bone is deposited, creating a bulge or spurs of irregular bone extending into the soft tissue. If the irritation ceases, the bone will slowly re-form so as to approximate its previous, normal condition. However, except for superficial injuries or those sustained during early childhood, some trace of damage persists for the life of the individual.

In terms of trauma, the most impressive of the Shanidar Neanderthals is the first adult discovered, known as Shanidar 1. This individual suffered a number of injuries, some of which may be related. On the right forehead there are scars from minor surface injuries, probably superficial scalp cuts. The outside of the left eye socket sustained a major blow that partially collapsed that part of the bony cavity, giving it a flat rather than a rounded contour. This injury possibly caused loss of sight in the left eye and pathological alterations of the right side of the body.

Shanidar 1's left arm is largely preserved and fully normal. The right arm, however, consists of a highly atrophied but otherwise normal collarbone and shoulder blade and a highly abnormal upper arm bone shaft. That shaft is atrophied to a fraction of the diameter of the left one but retains most of its original length. Furthermore, the lower end of the right arm bone has a healed fracture of the atrophied shaft and an irregular, pathological tip. The arm was apparently either intentionally amputated just above the elbow or fractured at the elbow and never healed.

This abnormal condition of the right arm does not appear to be a congenital malformation, since the length of the bone is close to the estimated length of the normal left upper arm bone. If, however, the injury to the left eye socket also affected the left side of the brain, directly or indirectly, by disrupting the blood supply to part of the brain, the result could have been partial paralysis of the right side. Motor and sensory control areas for the right side are located on the left side of the brain, slightly behind the left eye socket. This would explain the atrophy of the whole right arm since loss of nervous stimulation will rapidly lead to atrophy of the affected muscles and bone.

The abnormality of the right arm of Shanidar 1 is paralleled to a lesser extent in the right foot. The right ankle joint shows extensive arthritic degeneration, and one of the major joints of the inner arch of the right foot has been completely reworked by arthritis. The left foot, however, is totally free of pathology. Arthritis from normal stress usually affects both lower limbs equally; this degeneration therefore suggests that the arthritis in the right foot is a secondary result of an injury, perhaps a sprain, that would not otherwise be evident on skeletal remains. This conclusion is supported by a healed fracture of the right fifth instep bone, which makes up a major portion of the outer arch of the foot. These foot pathologies may be tied into the damage to the left side of the skull; partial paralysis of the right side would certainly weaken the leg and make it more susceptible to injury.

The trauma evident on the other Shanidar Neanderthals is relatively minor by comparison. Shanidar 3, the individual who died of the rib wound, suffered debilitating arthritis of the right ankle and neighboring foot joints, but lacks any evidence of pathology on the left foot; this suggests a superficial injury similar to the one sustained by Shanidar 1. Shanidar 4 had a healed broken rib. Shanidar 5 received a transverse blow across the left forehead that left a large scar on the bone but does not appear to have affected the brain.

None of these injuries necessarily provides evidence of deliberate violence among the Neanderthals; all of them could have been accidentally self-inflicted or accidentally caused by another individual. In either case, the impression gained of the Shanidar Neanderthals is of a group of invalids. The crucial variable, however, appears

to be age. All four of these individuals died at relatively advanced ages, probably between 40 and 60 years (estimating the age at death for Neanderthals beyond the age of 25 is extremely difficult); they therefore had considerable time to accumulate the scars of past injuries. Shanidar 2 and 6, the other reasonably complete Shanidar adults, lack evidence of trauma, but they both died young, probably before reaching 30.

Other Neanderthal remains, all from Europe, exhibit the same pattern. Every fairly complete skeleton of an elderly adult shows evidence of traumatic injuries. The original male skeleton from the Neander Valley had a fracture just below the elbow of the left arm, which probably limited movement of that arm for life. The "old man" from La Chapelle-aux-Saints, France, on whom most traditional reconstructions of the Neanderthals have been based, suffered a broken rib. La Ferrassie I, the old adult male from La Ferrassie, France, sustained a severe injury to the right hip, which may have impaired his mobility.

In addition, several younger specimens and ones of uncertain age show traces of trauma. La Quina 5, the young adult female from La Quina, France, was wounded on her right upper arm. A young adult from Šala, Czechoslovakia, was superficially wounded on the right forehead just above the brow. And an individual of unknown age and sex from the site of Krapina, Yugoslavia, suffered a broken forearm, in which the bones never reunited after the fracture.

This evidence suggests several things. First, life for the Neanderthals was rigorous. If they lived through childhood and early adulthood, they did so bearing the scars of a harsh and dangerous life. Furthermore, this incidence of trauma correlates with the massiveness of the Neanderthals; a life style that so consistently involved injury would have required considerable strength and fortitude for survival.

There is, however, another, more optimistic side to this. The presence of so many injuries in a prehistoric human group, many of which were debilitating and sustained years before death, shows that individuals were taken care of long after their economic usefulness to the social group had ceased. It is perhaps no accident that among the Neanderthals, for the first time in human history, people lived to a comparatively old age. We also find among the Neanderthals the first intentional burials of the dead, some of which involved offerings. Despite the hardships of their life style, the Neanderthals apparently had a deep-seated respect and concern for each other.

Taken together, these different pieces of information paint a picture of life among the Neanderthals that, while harsh and dangerous, was not without personal security. Certainly the hardships the Neanderthals endured were beyond those commonly experienced by modern peoples. Yet they provide the first evidence in the prehistoric record of human caring and respect as well as of violence between individuals. Perhaps for these reasons, despite their physical appearance, the Neanderthals should be considered the first modern humans. □



The right hand of Shanidar 4 demonstrates the enlarged finger tips and strong muscle markings characteristic of Neanderthal hands.

Mysterious Monthly Rhythms

by John D. Palmer and Judith E. Goodenough

Some plants and animals are governed by monthly biological clocks whose uses are not always clear

The kind of procreation occurring in humans, in which sperm are intimately transferred to the protective innards of the female, falls under the broad category of internal fertilization. As exemplified by humans, a high degree of cooperation is often required between the sexes to accomplish the act. The alternative, more passive category, commonly used by many aquatic organisms, is external fertilization, where, in an offhand manner, organisms simply liberate gametes into their environment and fertilization is mostly left to chance encounters of egg and sperm.

Since the pattern of external fertilization became established in nature, evolution has worked inexorably to make it more adaptive, that is, to increase a sperm's chances of actually uniting with an egg. One variation has been to simply increase the number of gametes produced. While this is an obvious improvement, gamete production can take up as much of an animal's everyday life as feeding and individual survival. For instance, in contrast to the human female who releases just thirteen eggs per year, the female oyster produces and sheds over 500 million eggs during the same interval. Obviously, a great deal of the animal's



time and energy is consumed in this project, an endeavor that, like any form of reproduction, does not directly benefit the individual but does benefit the species. Obviously, a mechanism that insured the persistence of the species but was less taxing to the individual oyster would be a fine improvement.

An oyster egg liberated into the sea must often drift for miles, remaining viable all the while, before—if ever—encountering a compatible sperm. This weak point of external fertilization can be counteracted if organisms live in dense colonies so that gametes do not have to travel far to unite. And most species, including those with internal fertilization, also produce their gametes rhythmically, perhaps at new or full moon. This helps insure that fertilization will take place and at the same time releases the organism from a life of full-time gamete production. The Samoan palolo worm (*Eunice viridis*) is an organism that has such a rhythm and also lives in proximity to its fellows, in honeycombs of cracks and crevices in coral reefs surrounding Samoa and Fiji.

Throughout most of the year this worm, like many other marine polychaetes, consists of a tentacle-bearing head followed by a string of more or less identical body segments. During the year the worm elongates by budding new segments from its posterior end. As the fall reproductive season nears, the newly produced derrière, called an epitoke, becomes fully mature. Each new segment is mainly a gamete-making machine that produces either eggs or sperm, depending on the worm's sex. This preparation completed, the worms enter into a ritual that usually begins about dawn on the first day of the last quarter of the moon in November. As if on a given signal, the epitokes of all the mature worms on the reef break off and swim to the ocean surface. There the writhing hemiworms begin to churn the tranquil ocean surface into a froth of decerebrate dancers. Then, again in a unison that appears to be a response to a universal command, the engorged epitokes explode, liberating their gametes into the sea. In this milky slurry, sperm finds egg and fertilization is consummated. Because of the precise timing of the gamete liberation, external fertilization in this organism has become increasingly efficient.

The natives of Fiji and Samoa are attuned to this worm's rhythms and performance. Just before dawn, the inhabitants position their canoes directly over the reefs where the worms will rise. When the worms' swarming frenzy commences, islanders scoop up strainers full and carry them back to their villages. Then, while Americans sit down to Thanksgiving turkey, the islanders



Donald Smetzer



Donald Smetzer

One dawn during the fall reproductive season, Samoan palolo worms rise to the ocean surface and release gametes into the sea. Taking advantage of the worms' precise timing, Samoans, left, harvest the animals, considered a delicacy. Right, islanders scoop up large catches of worms.



Oxford Scientific Films; Animals, Animals

also feast, their entree being delicious roast palolo epitokes.

Another marine polychaete worm, *Platynereis megalops*, lacks the palolo's interest for the gourmand but does provide an example of a further evolutionary improvement in fertilization success. In this animal's case, synchronization of reproductive readiness is coupled with a means of overcoming a lack of intromittent organs. Only during the summer months, between the last quarter of the moon and the new moon, does *P. megalops* produce gametes. Each evening during these intervals, for just two hours, the small reddish males of this species swim to the surface and dart rapidly around in roller coaster fashion. Soon the pale yellow females, their bodies lumpy with eggs, appear from the depths. Both males and females then begin a ritual that signals the last night of their lives. Unlike the males, the females' swollen bodies move sluggishly through the sea, for at this stage they are little more than swimming ovaries. When a male meets such a female, he immediately begins his nuptial dance of high-speed loop the loops. His gyrations culminate as he tightly entwines the female's body with his in a head-to-tail alignment. Thus embraced, she turns her head as if seeking his tail. Looping one last coil of his body around her head, he inserts his tail into her mouth. His intestine has become riddled with perforations, and now the sperm from his body cavity are swept through these holes into his gut and out his anus into the female. Her digestive tract has also become perforated so that the sperm move directly to the ripe eggs stored in her body cavity and fertilize them. Large rents then appear in her body and the newly formed zygotes escape into the sea, where they must develop on their own. The shredded body of the female sinks to the sea bottom, where she dies. The cavalier male may mate with several more females that night before he, too, dies.

Many marine algae also liberate their eggs and sperm on a periodic basis. Field ecologists have studied the brown algae *Dictyota dichotoma* most extensively, and as early as 1905, researchers learned that during the summertime, gametes of both sexes were shed into the sea twice each month, where fertilization was left to chance. The precise timing of gamete release attracted inquisitive botanists who wanted to learn the mechanism of control. The brown algae were therefore brought into laboratories and placed in aquariums where external conditions could be varied at the will of the observers. The algae were kept in man-made light–dark cycles, although the length of the period of illumination mimicked the long days of summer. Thus isolated from their natural environment, the algae did not release gametes at precise intervals. However, experimenters could reestablish periodicity by leaving the lights over the aquariums on for just one night to simulate full moon. Nine days later, for an interval of about three days, the algae shed a few gametes daily. Gamete production then stopped, but about seventeen days later a second, much larger burst occurred. And from this time on, at approximately seventeen-day intervals, the algae liberated gametes, thus displaying an approximate bimodal monthly rhythm. Isolation in the laboratory meant that algae were not receiving any cues as to the day of the month. But the algae acted as if they possessed a living clock within their tissues.

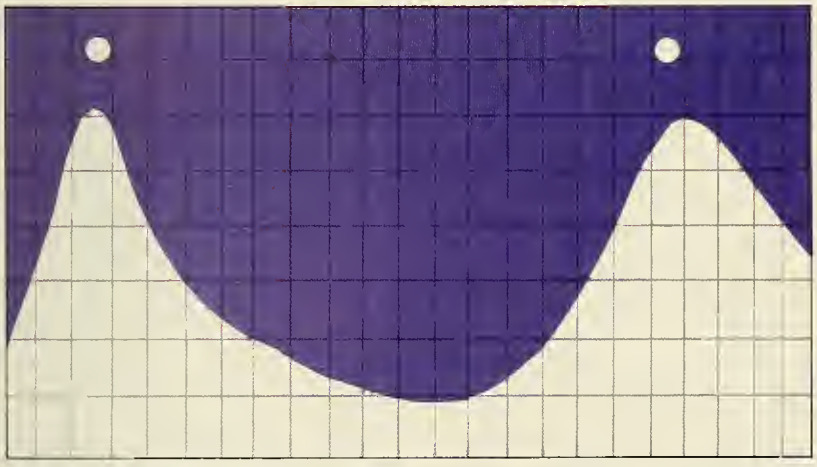
Hence, one of the best improvements evolution has made on external fertilization is synchronization of the mating readiness of male and female, as in internal fertilization. Furthermore, the phase of this readiness has been tuned to particular stages of the moon's waxing and waning so that, depending on the organism, gamete liberation is often synchronized with full or last-quarter moon, when the moon is visible above the horizon at night. And evolution has carried the modifications even further by providing each organism with its own means of timing, a biological clock that signals in advance when full moon is due. Thus the organism can complete the physiological preparations for breeding before the important night. The possession of a monthly clock is a feature of many organisms, but the uses some animals make of this clock are not as obviously adaptive as those of the Samoan palolo worm or the brown algae.

For instance, the ant lion displays a curious clock-controlled rhythm. Many adults have childhood mem-



Robert Mitchell; Animals, Animals





John D. Palmer and Judith E. Goodenough

Above left: The size of pits dug by ant lions varies in a monthly rhythm. Above: An ant lion captures an ant as it slides into a pit. The chart at left indicates the monthly change that occurs in the size of ant lion pits between full moons.

ories of playfully dangling grass stalks into the conical pits constructed by ant lions, which then hurled sand at the presumed prey. The ant lion is a six-legged larval insect with an oval body and a pair of extraordinarily long, hollow jaws with which it sucks the juices from its victims' bodies. Widely distributed in sandy areas of the United States, the ant lion digs a pit in the sand, then waits at the base for small insects, primarily ants, to slide into the trap. To insure the victim's capture, the ant lion tosses sand at it, causing it to quickly slide into the open jaws at the pit bottom.

When researchers made careful daily measurements of the size of these pits, they observed that the volume of pits is greater around the days of full moon than those of new moon. This monthly rhythm in pit volume will persist even when the ant lions are cloistered for months at a time in the laboratory in constant darkness and temperature.

There have been several attempts to explain this rhythm, but when each hypothesis was experimentally explored, it had to be discarded. The most plausible suggestion was that the size of the pit must vary with the availability of food. Ants can escape more easily from small pits, so the large pits constructed at full moon would be more efficient traps. But when these small invertebrates known to be relished by ant lions were trapped nightly in the surrounding habitat, there was no indication that their numbers cycled in abundance. Furthermore, limiting captured ant lions to one ant per day had no effect on the monthly pit-volume rhythm.

Another rhythm for which there is no apparent adaptive purpose occurs in a freshwater planarian, a small flatworm. Researchers accidentally discovered that when a population of flatworms is maintained in the laboratory, the angle each worm assumes in swimming away from a lighted area varies with the phase of the moon. A very



J.A.L. Cooke; Animals, Animals



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The large organism at left is a small green species of planarian flatworm, found in freshwater in Australia. Above, these larger planarian flatworms, also freshwater species, live in Tamana Cave, Trinidad.

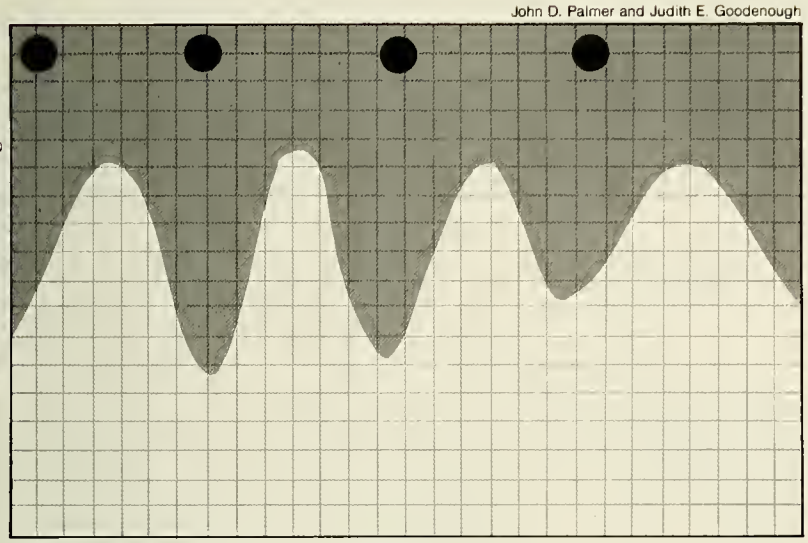
simple apparatus, a great deal of patience, and a high tolerance for repetitive observations are all that are required for the study of this spatial orientation rhythm. The apparatus consists of a grid marked off into 5° sectors, with a small dish of pond water placed over it. A flatworm is positioned in the dish at a starting point, and the angle it assumes in escaping from two beams of light is measured by noting the sector it is in as it crosses a finish line. When many worms are tested in this way, and the average angle assumed by all the worms plotted for each day of the month, the angle at which the animals turn away from the lights is greater at one time of the month than at another. This rhythm also persists in the absence of all common environmental time cues, meaning that planarians also possess a monthly clock.

The prevalence of monthly rhythms, and their persistence in constant laboratory conditions, has triggered a considerable amount of speculation about the nature of the biological clock that governs them. One popular explanation is that a monthly rhythm is produced by the interaction of two other rhythms, one having a solar day period (24 hours), the other, a lunar one (24.8 hours). Rhythms with both these period lengths are very common throughout the plant and animal kingdoms. As examples, solar-day rhythms are expressed as sleep–wakefulness alternations in cockroaches, birds, and rats, as well as in humans. Solar-day rhythms rule cell division in mice and men, food gathering in bees, and respiration and photosynthesis in plants. Even single-celled organisms display such rhythms. Lunar-day rhythms are also common, especially among shore-dwelling organisms. Many beach crabs scurry about the tidal flats during low tide, but return to their burrows shortly before high tide for the duration of inundation. Living clocks control both solar- and lunar-day rhythms. An ability to measure these intervals of time is highly adaptive because it allows organisms to anticipate and prepare for regular changes of the environment, such as the coming sunrise, the next high tide, and so on.

Some organisms—especially those living in the intertidal zones of seacoasts—display both solar- and lunar-day rhythms, often in the same physiological or behavioral process. The common fiddler crab darkens its body coloring during the daytime and also during each low tide. Thus when low tide occurs during the daylight hours, the crabs become especially dark.

In a particular organism, solar- and lunar-day clocks may interact to generate a monthly rhythm. The peak of a solar-day rhythm comes, of course, at the same time each day. Because the lunar-day rhythm is 24.8 hours in length, its single peak occurs, like tides, fifty minutes later each day. Only once a month do the peaks of lunar- and solar-day rhythms coincide, and then, because their effects are additive, the process controlled by the clocks reaches an extreme value, as when the fiddler crab's body color becomes extremely dark. This idea of the generation of monthly rhythms is called the beat hypothe-

John D. Palmer and Judith E. Goodenough



Worms kept in a laboratory for a four-month interval increased their counterclockwise turning movements about the time of each new moon.

sis, and it can be tested quite simply.

Solar-day rhythms will synchronize with artificial day–night cycles created in the laboratory. For example, a typical 24-hour biological rhythm will become 20 hours long when an experimental animal is subjected to light–dark cycles consisting of 10 hours of light, alternating with 10 hours of darkness. Lunar-day cycles ignore the transmuted day lengths. Therefore, the following experiment was performed with the planarian spatial orientation rhythm.

Populations of these flatworms were maintained under different light regimes. One group was kept in a light–dark cycle with 12 hours of light and 12 hours of darkness—a 24-hour day. According to the beat hypothesis, the 24-hour solar-day rhythm would interact with a lunar-day rhythm to produce a monthly peak at approximately thirty-day intervals. A second group of planarians was exposed to 20-hour days, a light–dark cycle of 10 hours of light followed by 10 hours of darkness. This slight shortening causes the solar-day rhythm to align with the lunar-day rhythm at scant five-day intervals. A third group, exposed to 28-hour days, would cause the new daily rhythm to interact with a lunar one at seven- to eight-day intervals.

The orientation responses of these groups of planarians were followed for several months. All three groups displayed the same approximately thirty-day rhythm. Evidently the planarian monthly oscillation is not produced by a beat phenomenon between lunar- and solar-day clocks.

Perhaps organisms also possess a slow-running clock that is capable of measuring monthly intervals. If this is true, the mechanism of the monthly horologe may be similar to that of the clocks driving solar- and lunar-day rhythms.

The best way to test for a similarity in mechanism would be to see whether the monthly clock shares the well-documented sensitivity of the solar-day oscillator to a chemical called deuterium oxide, or heavy water. When administered to an animal or plant in the constancy of the laboratory, deuterium oxide will increase the period length of a solar-day rhythm. If monthly rhythms were also lengthened by this substance, this might indicate a similarity in the mechanisms of these two biological pacemakers.

To apply this test to the planarian spatial orientation rhythm, groups of the flatworms were cultured in low concentrations of heavy water. But deuterium oxide had no effect on the period length of the animals' monthly rhythm. While this finding certainly does not preclude the existence of an endogenous monthly clock, it does indicate that if such a clock exists, its mechanism is somewhat different from that of a solar-day clock.

Another hypothesis to explain monthly rhythmicity suggests that the required timing information is obtained from some geophysical force in the environment that undergoes a monthly rhythm in intensity, is able to penetrate the constancy of the laboratory, and can be used by organisms to sense the day of the month. In this case, the biological clock would be a receiving and signaling mechanism within the organism that can couple this subtle environmental information to behavioral and physiological processes. Although organisms are sensitive to an array of geophysical forces, including magnetism, electrostatic fields, and background radiation, there is as yet no proof that one force is the key to the generation of monthly rhythms.

Thus, as so often happens in the early stages of a new scientific endeavor, there is no proven explanation for a very evident biological phenomenon. Although the widespread distribution of monthly rhythms throughout the living kingdom emphasizes their importance, the adaptive significance and even the function of some remain obscure. Because these rhythms persist in organisms deprived a view of day–night alternations and the changing faces of the moon, they must be controlled by some sort of clock within living cells. At present, there are few clues to this clock's mechanism, but there are some indications as to what it is not. Apparently its periodicity is not generated by an interaction of the shorter frequency solar- and lunar-day cycles, and the mechanism seems to be physiologically different from that of a solar-day clock. Each month, the full moon reminds us of its importance to life on earth and of the way the interval created by its waxing and waning is mimicked in many organismic physiological and behavioral processes. □

The Life Cycle of Cellular Slime Molds

by John Tyler Bonner
photographs by David Scharf

Instead of remaining solitary and unicellular like other soil amoebae, some slime molds become social and multicellular

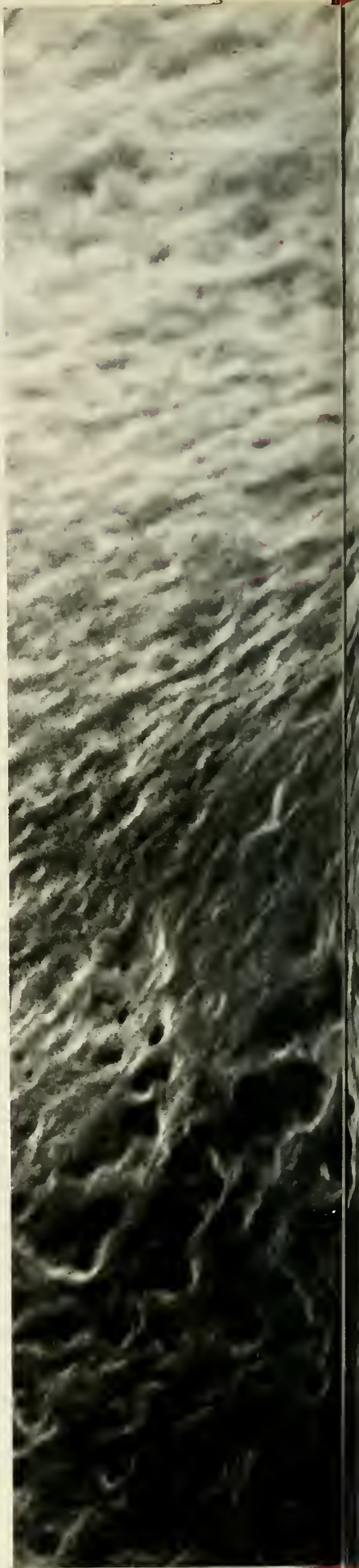
The great advances of molecular biology in the past forty years come largely from the study of a single bacterium, *Escherichia coli*. This primitive procaryotic organism, which lives in the intestine of man and other animals, can be easily grown in the laboratory. Its generation time, depending on conditions, is between twenty minutes and one hour, and the total number of genes and other molecules this minute organism possesses is small compared with any higher animal or plant.

In the last few years, however, scientists have been pondering a new and important question: Do all the wonderful facts and principles that apply to *E. coli* and that have revolutionized molecular biology also apply to higher organisms like man? Most workers agree that understanding the mechanism of how a higher organism develops is of enormous interest and importance. The obvious first step is to see what principles derived from *E. coli* apply and what new ones must be discovered.

But how can biologists and biochemists best attack the problem of the development of higher organisms? Experimenters cannot, after all, experiment on man, and even mice and rats are enormously complex and slow in their growth. Nevertheless, such studies on the embryos of many animals, including sea urchins and salamanders, have been pursued for the last hundred or more years and we know many of the basic, overriding rules of development. What we want to understand are the underlying molecular mechanisms.

Looking for a simpler system that can be analyzed in its minutest parts, some biologists have very successfully turned to tissue culture, the growing of mammalian cells of different tissues in suitable nutrients in the laboratory, much as *E. coli* is grown. In this way the differentiation of one cell type or the interaction between a few cell types can be studied in molecular detail. Other biologists have picked lower multicellular organisms that have a simple, relatively short growth cycle and some of the properties of mammalian development. The cellular slime molds are such organisms.

True slime molds (myxomycetes) are primitive organisms that have both funguslike and protozoalike properties. In their feeding stage, they are multinucleate: their nuclei are not separated into cellular compartments. They are capable of movement and absorb organic food from vegetable matter and bacteria as they move in moist soil and across logs, twigs, and leaves decaying on the forest floor. Cellular slime molds are another form in which individual amoebae aggregate without fusing to form a multicellular fruiting structure.

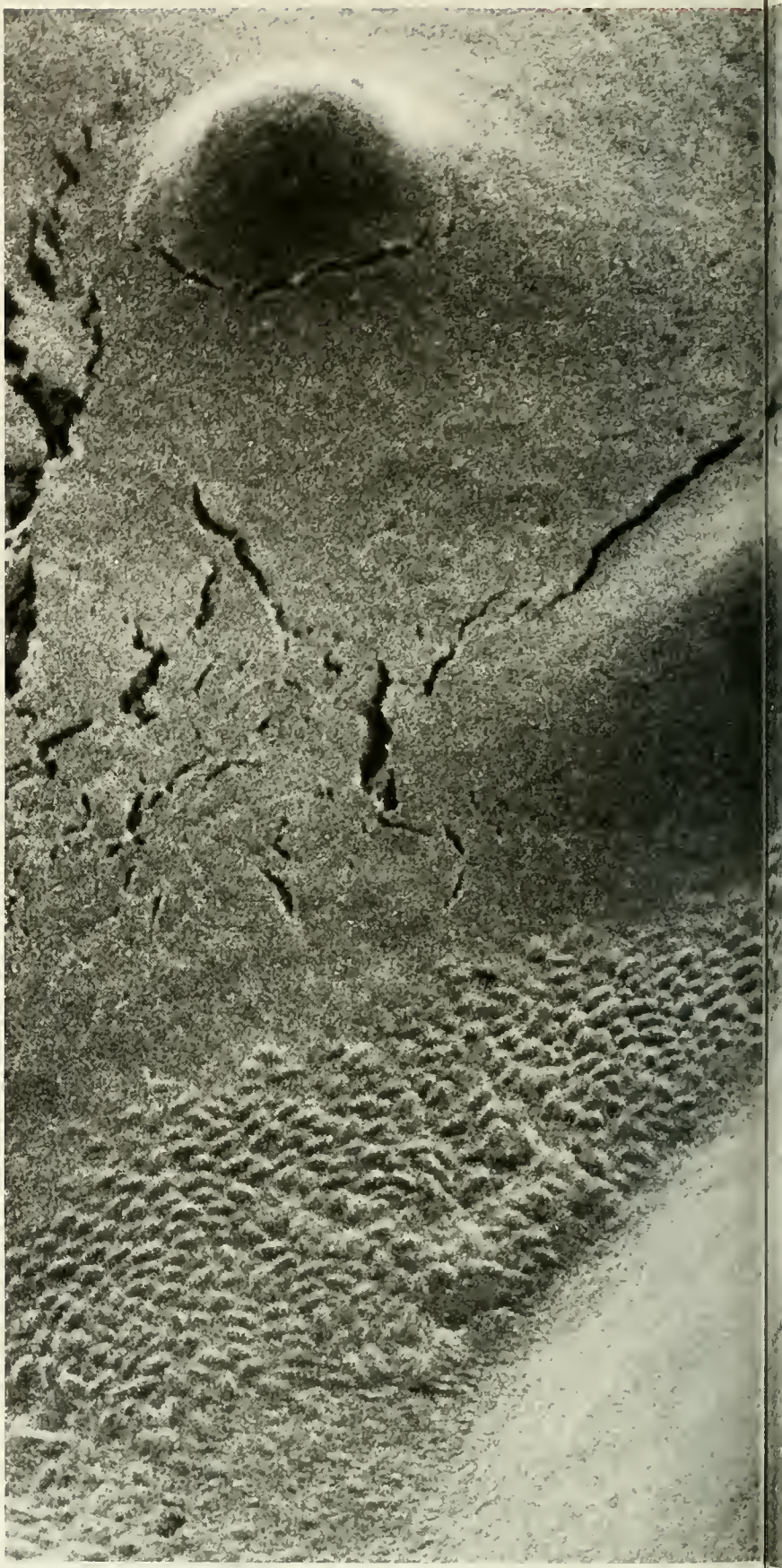


As a potential spore tower rises higher, it grows thinner at the base, where amoebae continue to stream in.

840X



After slime mold amoebae have fed on bacteria, they begin to come together to form spore towers. Inside the slime, or skin, of each hump are thousands of amoebae.



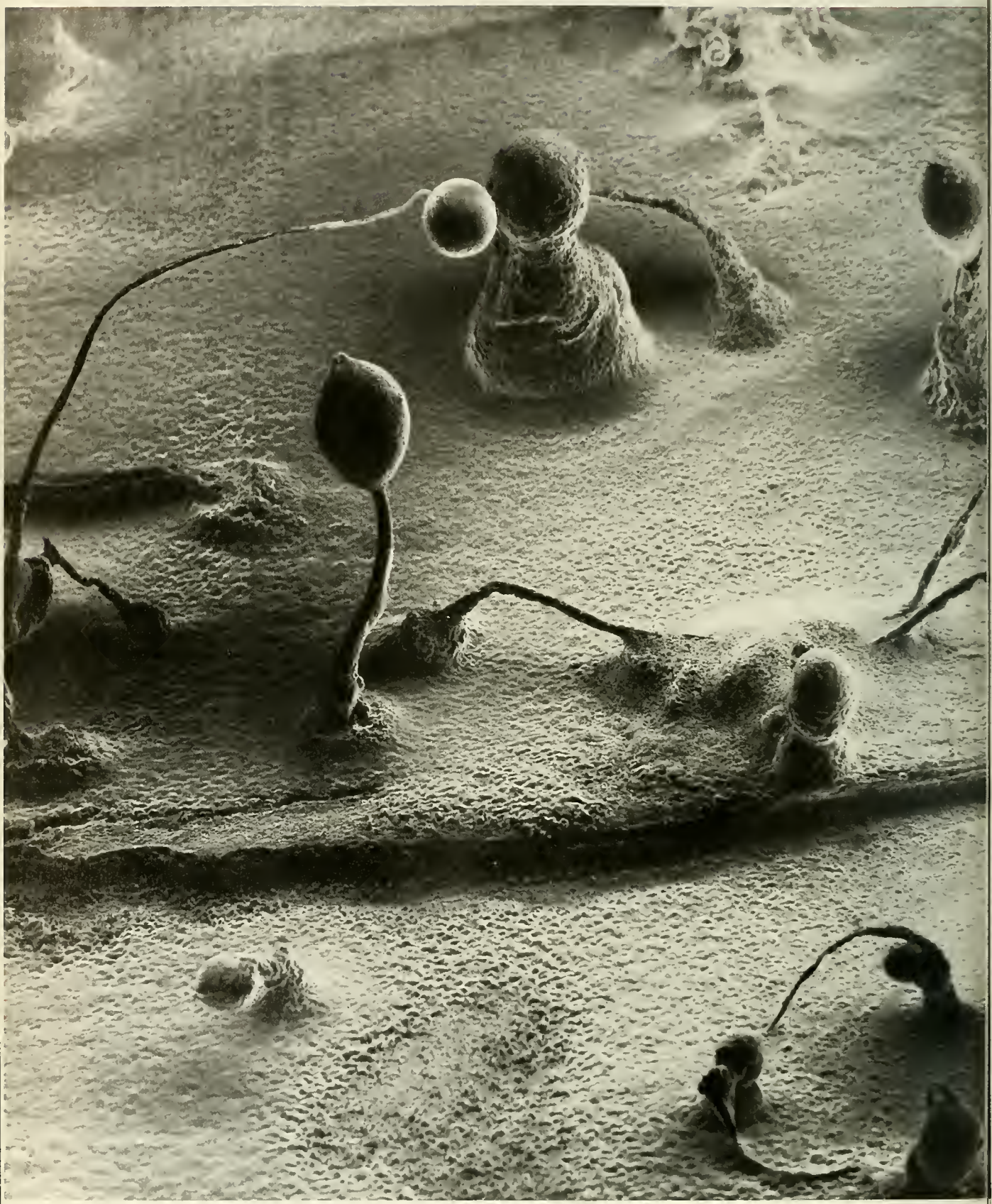
Cellular slime molds have been known for over a hundred years, but the current wave of interest started in 1935 with the discovery of the species *Dictyostelium discoideum*. In some respects, it is a multicellular *E. coli*, a cooperative eucaryote suitable for experimental molecular studies on development.

But in many ways the most remarkable aspect of the cellular slime molds is their life history. When I began working on them in the 1940s, every time I gave a talk on my research I would have to spend at least fifteen minutes on their life cycle, and when the question period came, I always felt people were far more interested in the strangeness of the organisms than in my experiments. In the intervening years, *Dictyostelium* has almost become a household word among biologists. *Dictyostelium* is a genus of soil organism in which the principal cell unit is an amoeba. The feeding cells of cellular slime molds are among the common amoebae found in the soil and appear to be closely related to the solitary soil amoebae, which have been known to the zoologist for many years. At the feeding stage, cellular slime mold amoebae are, in fact, indistinguishable from other amoebae, for they also are solitary; they have not yet entered their multicellular, or "social," stage. This is a very important feature of their life history: they feed and divide (grow) as separate cells, mopping up the bacteria in the soil and leaf humus. In this way the process of growth is separate in time from the form-making processes, called morphogenesis, and the division of labor among the cells, called differentiation. Because of this separation, the two fundamental processes of development can be studied independently.

After they have cleaned an area



810X



110X

Tall spore towers, or fruiting bodies, are fully mature. New towers are still rising.

of bacteria, the independent amoebae will suddenly become strongly attracted to one another and join together in large masses of cells. The trigger for this aggregation of cells is starvation. The amoebae are attracted both to one another and to central collection points; the result is a series of beautiful streams of elongate amoebae, which enter the centers like the spokes of a feathery crystal. We now know that the amoebae are attracted to one another by a chemical substance called acrasin, which is given off by the amoebae themselves.

There also exists another substance, an antiacrasin—perhaps better called an acrasinase—that destroys acrasin. Acrasinase is a protein enzyme that destroys the active acrasin, much as the enzymes in our stomach break down the food we eat. The chemical identity of both the acrasin and the acrasinase of some species, including *D. discoideum,* was discovered about ten years ago. Their acrasin is a small molecule called cyclic AMP, which also plays an important part in many of the chemical signaling systems in our own bodies, including a role in the action of hormones and the transmission of impulses from one nerve to another. Because this particular chemical messenger is so important in general for all living forms, many scientists have become particularly interested in the study of *D. discoideum* acrasin. Again, the acrasinase is an enzyme very similar to one that breaks down cyclic AMP in the body of any higher animal.

Once the amoebae have all come together into a mass, they form a cigar-shaped structure, sometimes called a slug. Slugs vary in size from 0.2 millimeters, containing only a few hundred cells, to large ones of up to 2.5 millimeters, containing many thousands of cells. If the conditions are right, and these seem to include high humidity (recent studies suggest that high atmospheric ammonia also helps), the slug will migrate for long periods of time. It is very sensitive to its environment and will go toward exceedingly faint sources of light and up very slight temperature gradients. After a period of this directed migration, again if conditions are right, the slug will stop its migration and begin the formation of the final fruiting body. The conditions that favor this step are a decrease in the humidity; an increase in the overall light, which may lower the humidity; and a decrease in the ammonia content of the air.

The building of the fruiting body, or culmination stage, is a complex process, involving a simultaneous movement of the cells and cell differentiation into two cell types: the stalk cells and the spores. The anterior cells of the slug are destined to become stalk cells. They first form inside the tip of the upright slug, and by continually forming new stalk cells at the tip, push the stalk shaft down through the posterior cells to the substratum. The presumptive stalk cells then keep moving to the tip where they become trapped in a cellulose cylinder that they have secreted; their movement is like that of a fountain where the water is moving backward. As the cells become part of the stalk tip, they swell, becoming engorged like plant pith cells, and die. Each dead stalk cell is surrounded by a thick cellulose wall and lies within a delicate, tapering cellulose cylinder. In *D. discoideum* the cylinders may rise 0.1 to 5 millimeters into the air. All the posterior cells become spores and are lifted as a

This spore tower is midway in its upward voyage. The spores mature as the tower rises.



1,560X

Mature spore cells and some stalk cells (at the top) are clearly visible on this spore head. As stalk cells form (at the tip), the head continues to rise.



group by the rising stalk cells. The end result is a minuscule model of a slender water tower. Each spore is a single amoeba encapsulated in a cellulose wall that is resistant to periods of drought and other harsh environmental conditions. If any one of these spores is sown in an environment suitable for growth, it will split open and the emerging amoeba can start a new generation.

Some species or strains of slime mold possess two other kinds of resistant bodies. One is a microcyst formed in a number of species related to *D. discoideum*. Microcysts form without aggregation; after feeding, each individual amoeba encysts and forms a thick cellulose wall. In this respect it is identical to many of the solitary soil amoebae, which never have any social stages at all. Apparently, in the microcyst-forming slime molds, the question of whether the amoebae will form microcysts or whether they will aggregate and form fruiting bodies depends on the environmental conditions. In particular, a high concentration of ammonia favors the microcyst route, while low ammonia produces normal fruiting bodies.

The other resistant body is the macrocyst, a large globule that has recently been shown to be the species' sexual stage. If the amoebae of opposite mating types find one another, and the environmental conditions are favorable, they loosely aggregate together. There will be a fusion of two cells, the start of the cyst, and a series of interesting changes in the cell activity inside the cyst. Ultimately, when the macrocyst germinates, it produces amoebae that share genes from both parents. Among the conditions that favor macrocyst formation is extreme moisture, especially a flood, which submerges the cells. Macrocysts also form better in the dark. Regular fruiting bodies are favored in the light; some species must have light to culminate.

To understand the evolution and ecology of cellular slime molds, an investigator must ask why they have these social, multicellular stages; why do they not remain unicellular like other soil amoebae? After all, they feed as separate cells; they could easily encyst, as the microcyst-forming species do some of the time. Furthermore, making multicellular masses is a costly process: all the stalk cells die. Since stalk cells represent about one-third to one-fourth of the cells (even more in some species), the organism must make a considerable sacrifice to produce the pretty little structures that shoot up into the air. The added expense means fewer spores, which could mean fewer chances that genes are perpetuated in future generations.

As a staunch believer in Darwinian principles of evolution and natural selection, I can only conclude that there must be some advantages that more than offset these disadvantages. And those advantages must specifically be ones that provide reproductive success. There must be something about a fruiting body sticking up into the air that makes reproduction more effective, at least in some circumstances, than solitary cysts. If this were not the case, the social amoebae would never have arisen during the course of evolution.

Becoming multicellular is not a feature unique to cellular slime molds; there are even other unrelated organisms that do so by a similar cell aggregation. Multicellularity must have developed many times during the course of evolution, and each time there is a similar problem of cost. Moreover, the cost increases with the size of the animal. Human beings are immensely expensive in the sense that the proportion of our cells involved in reproduction is minute. All the rest of our tissues die each generation. In modern Darwinian

730X



With maturity, the spore head's outer sheath of slime disappears.

terms, our bodies are nothing more than complex carriers for the genes in our reproductive cells. Large, complex bodies effectively protect their genes in the competition with other organisms for food, for survival. Large bodies are one possible strategy that small ones cannot manage. Thus, large animals find new ways to perpetuate and perhaps even increase the number of copies of their genes in successive generations.

There is one more point that is at the nub of sociobiologists' ideas concerning kin selection. They say that one reason why the many social animals congregate together is to protect their genes. Hence, altruism toward closely related individuals could be construed as a selfish act in which one organism is insuring the protection of genes identical to its own. These shared genes will be especially prevalent in immediate relatives. This sociobiological argument applies with full force to cellular slime molds. If all the amoebae in a small region of the forest humus come initially from one spore, the whole population (which results from a series of binary fissions of the original amoeba) will then be genetically identical; each amoeba will have

the same genes. The amoebae then have a very strong reason to help one another, and the altruistic sacrifice of the dying stalk cells is mitigated because all the spores share their genes and will carry life onward.

While these arguments make it reasonable that cells closely related genetically could help one another, they do not explain what the specific gains might be for small fruiting bodies in the soil. The most obvious hypothesis is that the fruiting bodies provide a more effective dispersal of spores. There must be some circumstances in which having the spores up in the air on a small stalk helps spread them over greater distances and gives them a better chance of starting new generations. Hints as to what these advantages might be come from a number of properties of the fruiting bodies.

First, they will always rise at right angles from the substratum. As they rise into the air, they give off a repellent gas. The fruiting bodies concentrate the gas equally on all sides, thus maintaining a perpendicular orientation. If two fruiting bodies rise side by side, they will lean away from one another. If they rise near a cleft, a crack, or a tunnel in the soil, they will always lie in the middle of the space available. Thus the spore mass will be in a position where the chances of its being touched by a passing worm or insect or other soil invertebrate are maximal. If any object touches a mass of mature spores, they will immediately stick to the passing body, much as a water drop might be transferred from the tip of a pin to a finger brushing by. Scientists do not know whether this is precisely what happens in the soil, but it is a reasonable guess. If attaching spores to passing animals is an effective method of dispersal, then this could more easily be achieved by multicellular fruiting bodies than by solitary microcysts.

The multicellular slime mold shows additional clever adaptations that further help effective dispersal of the spores. For instance, feeding must occur in a thin film of water where bacteria will grow. This is probably not the ideal place to meet passing insects and other animals, so *D. discoideum* has devised a method of migrating from the feeding region to an optimal spore-dispersal region. The slug can migrate considerable distances and will move toward sources of light and heat. In the soil this means closer to the surface. But the slug is at a vulnerable stage; to avoid shriveling, it requires a high humidity. An extremely slight drop in humidity, an increase in light (which may affect the humidity), and a decrease in the ammonia fumes all conspire to signal the slug to begin its fruiting, its culmination. Presumably, the reason this system is so sensitive is that it provides sufficient time for fruiting to occur before external conditions become dangerously dry.

This question of timing may be why some species have both fruiting bodies and the more primitive microcysts. Building fruiting bodies requires some time, but microcysts can be formed quickly. If adverse conditions come on too rapidly, the microcyst route might be the safer one. Also, having two methods reduces the risk of being wiped out completely, and for some species this risk might be greater than others. The only clue is that high ammonia gas pushes the amoebae into the microcyst route. Perhaps in some places where there is a large breakdown of proteins due to decomposition by bacteria and other microorganisms, the richness of the degradation makes fruiting body formation impossible; the bodies would be poisoned. To avoid this fate, the slime molds quickly form microcysts. In such a nutrient-rich area, after the decomposition has subsided, the microcysts may split open and liberate their amoebae, which then produce a normal life cycle with fruiting bodies that are effective in dispersal. In *D. discoideum*, ammonia favors migration, permitting the slug to move away from the toxic region.

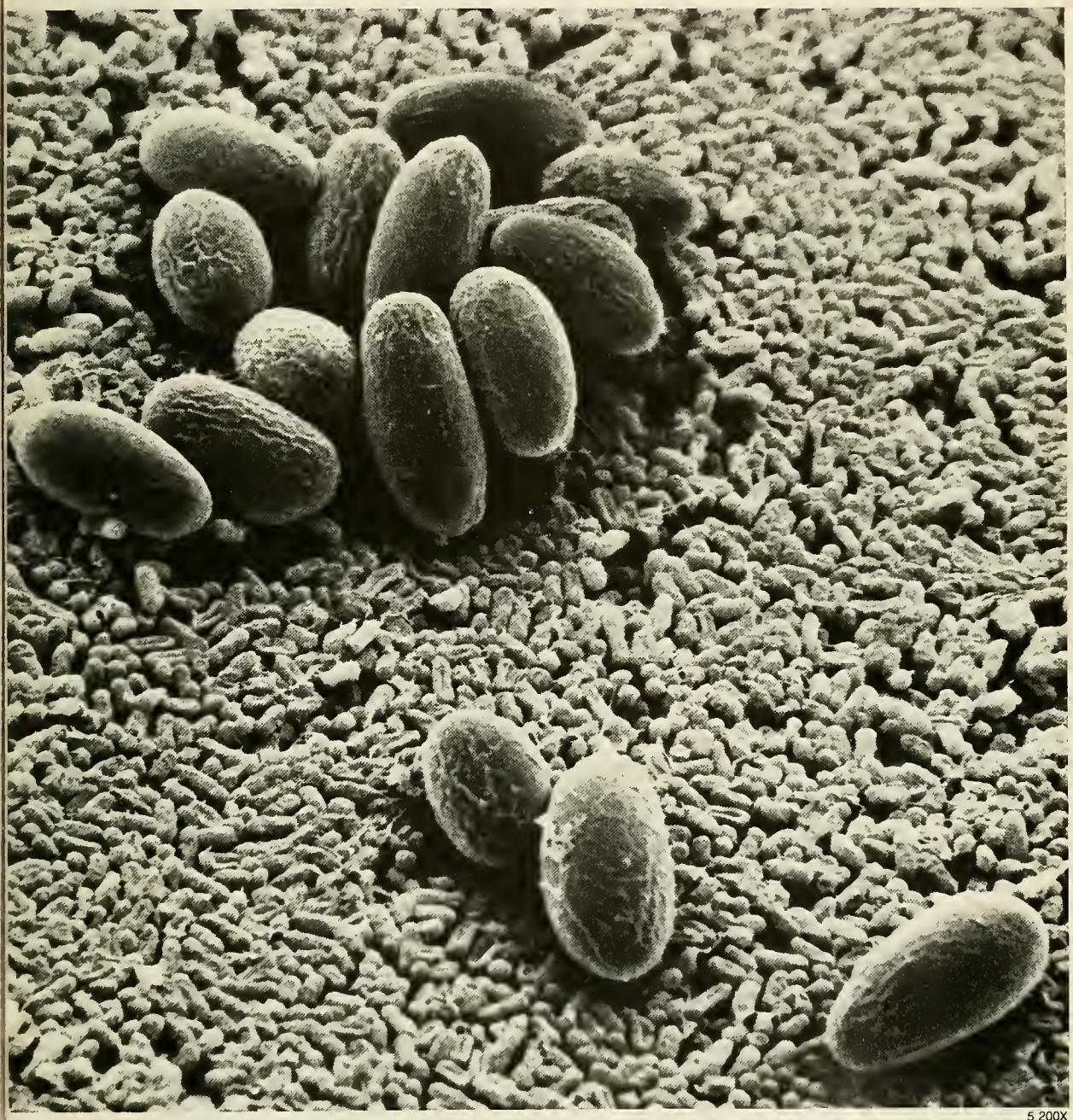
An explanation for macrocysts might be somewhat different. Since the prime stimuli for macrocyst formation are an excess of water and darkness, one argument could be that normal fruiting bodies and microcysts protect the genes when there is a drought, while macrocysts are the protection mechanism for a flood. If the rains come and the amoebae are still feeding in the dark underground, they can rally, even when submerged, and produce a macrocyst. If they did not, they would die: slime mold amoebae cannot survive long periods underwater, but the tough macrocyst can. There is one possible objection: that this could only occur if both mating types happened to be together at the same time as the downpour. For some strains this would certainly be true. However, there are other strains that are apparently capable of self-fertilization and therefore could form macrocysts without a partner.

Strains that always self-fertilize have lost the ability to take advantage of the gene reshuffling that makes sexuality such an important mechanism in governing variation for evolution. From a genetic point of view, self-fertilization amounts to asexual reproduction. But if opposite mating types come together, then there are all sorts of chances for gene rearrangements; the offspring that crop out of the macrocysts will show a new range of variation, that is, some combination of the characters of the parents. One could argue that if the new amoebae that appear after a major environmental upheaval, such as a heavy rain, are facing a changed environment, some of the variable amoebae that issue forth from the macrocyst might be especially well suited in the competition for food and effective dispersal in the new environment. This would be a perfect example of natural selection at work in a changing external world.

I have argued that cellular slime molds have become social because a multicellular fruiting body is an

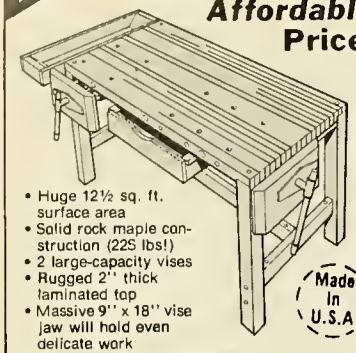
These mature spores have dispersed onto a bacteria colony. Each spore may split open, and a single amoeba may emerge to feed on bacteria and begin the slime mold life cycle anew.

effective way of spreading. There is another reason to support this argument. In soil and in humus, and on the surface of any object in a moist forest environment, there are multitudes of small, spore-bearing fruiting bodies of many different species other than cellular slime molds, which are not the only ones to have exploited this method of dispersing their spores. Most of the other species that do this are fungi. They vary enormously in size, and one can find a range from microscopic molds, whose fruiting bodies are no larger than those of small cellular slime molds, to huge mushrooms. Some molds rely on insects and passing animals to spread the spores, while others use wind and even moving water. Besides the myriad fungi, there are the true slime molds (myxomycetes), which have quite a different kind of life cycle from the cellular slime molds discussed here. Finally, there are even examples among bacteria. The slime bacteria (myxobacteria) are social in a way that is remarkably parallel to *Dictyostelium*, and they produce minute fruiting bodies up to a millimeter in height. If this kind of dispersal structure is so widespread and has been developed in so many lower organisms, it is probably adaptively advantageous. In each case, the selective advantages have been well worth the cost of construction. □



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The Inner Eskimo

THE LAST AND FIRST ESKIMOS, text by Robert Coles, photographs by Alex Harris. *New York Graphic Society, $19.95; 160 pp., illus.*

White visitors to the Arctic often react strongly to that vividly different environment with its striking patterns of light and darkness, its bitter winters and giddily bright, soft summers. The summers they find exhilarating, although some are troubled by the sunlit nights, which make sleep come slowly. The winters are felt as burdensome and depressing, restrictive of both outer and inner movement.

Visitors who have dealings with Eskimo, who "study" them or live with them for shorter or longer periods, often come away with the impression that Eskimo personality is predominantly practical, pragmatic, finely tuned to coping with a physically demanding environment, but lacking in introspective, reflective, and imaginative qualities. Reading such accounts, one sometimes wonders whether Eskimo have an aesthetic sense—whether they notice the changing seasons in other than practical terms, such as, time to move to a new campsite, to get out the boat or put away the snowmobile.

Robert Coles's book *The Last and First Eskimos* is a good antidote to this overly simple view of Eskimo personality. One has the impression that the four Eskimo who speak through his text are both aesthetically alive and emotionally absorbed—at times with a tormented intensity—in their physical environment. Coles has focused each of his four chapters on one of the striking physical phenomena that characterize the Arctic scene: winter darkness, wind and snowstorms, the 24-hour daylight of summer, and the vast spaces of the north Alaskan landscape, both out over the Bering Sea and inland over the tundra. The chapters consist largely of lengthy quotations from an elderly grandmother, a young



Alex Harris

father, a mother, and a fourteen-year-old girl, respectively, and all of their words are poetic. Sometimes the imagery is reminiscent of Cape Dorset prints with their vivid spirit-animals and spirit-persons.

The views of the cosmos presented by these four speakers are individual, differing from one another in the emotions and fantasies attached to seasons and landscapes. They are similar only in that intense emotions and fantasies are attached to these phenomena. The physical world appears to be a focus of Eskimo concern and, sometimes, a metaphor for other, human concerns: personal strengths and weaknesses, the quality of life past and future—its sadness, joys, forebodings, hopes, and moral dilemmas.

The trouble is that there is something a little unreal about all this. The Eskimo I know (some of them, sometimes) may think like this (I don't know), but they never talk in this way, even in their own language, much less in English. Is Coles exceptionally skillful at eliciting flowingly articulate, free-associative statements? Are these exceptionally poetic individuals? Or has a great deal of editing been done? If the last, we should be told and some of the quotation marks should be removed. Sometimes I recognize a point of view that strikes me as familiarly Eskimo—"You cannot survive if you forget how to be scared," "We didn't talk as much then as people do now," "[My father] always squeezed [my shoulder] when he was afraid I was not paying attention, or I was too much asleep," "There are moments when I am afraid of my own thoughts"—but the phrasing is often un-Eskimo to my eye. Indeed, it is often difficult to tell where the quotation begins and ends, as the somewhat turgid quality of Coles's own prose carries over and makes me wonder whose words are being spoken.

Coles's interpretations of the underlying meanings of quotations and the content of unspoken thoughts are not always justified by the evidence contained in the quotations. I would like to see an Eskimo review of this book. Would the people of the villages Coles visited recognize their thoughts? What did Coles ask that elicited these statements?

There is another problem, too. I have said that the book is a good antidote for the impression that Eskimo are almost exclusively pragmatic people. However, the book's single-minded focus on emotional responses to seasons,

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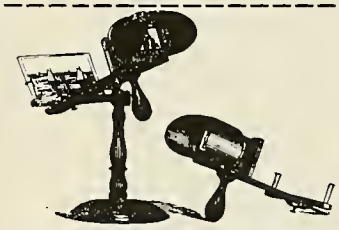
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Alex Harris



weather, and landscapes is, I am afraid, likely to give rise to the opposite misconception: that Eskimo are preoccupied, perhaps even to the point of obsession, with these phenomena. Again I am left wondering about the extent of Coles's own influence on this presentation. I am sure that these things are important to Eskimo, as they are to any people who live in touch with the land and derive their livelihood from it, especially a land that has the power to take lives, as the Arctic does.

Even so, I felt somewhat overwhelmed by the apparent intensity, the driven quality, of this preoccupation with weather on the part of the four narrators. Is this a true impression or is it perhaps Coles, the visitor from the "lower forty-eight," who is preoccupied with the physical world of the Arctic? Is Coles the psychoanalyst searching for possibly disturbing effects and finding what he looks for: "The agitation of the summer, the curious, unreal, mental state that falls upon him and other Eskimos." At several points the suspicion arises that Coles may have chosen exceptionally sensitive subjects. The old lady who talks about "the madness of darkness" remarks, "I have always been trouble to others because of my fears," and she speaks of a time when she "went wild" and people later told her she had "gone mad." The young man who describes the disturbances he experiences in the light and heat of summer says that a priest told him that he might have a sickness; in the army, they "did tests" on him to see why the light went to his head but found nothing wrong. I, too, know Eskimo who are very intense and who fear that their feelings will drive them "crazy," but Coles's book gives the impression that most Eskimo are like this, and I think that may be a mistake.

Finally, fascinating as it is, the focus on dramatic feelings related to the environment distracted my attention from the stated purpose of the book: to express the views of the several generations of Alaskan Eskimos face-to-face with cultural transition and their various responses to change. The transition, and feelings about it, are often visible in what the narrators say, but I had to search for it, and I found it mostly on rereading.

Happily, the superb photographs by Alex Harris do much to counteract the one-sided emphasis of the text. For one who has lived with

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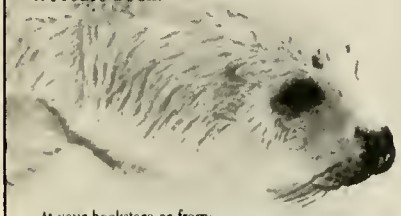


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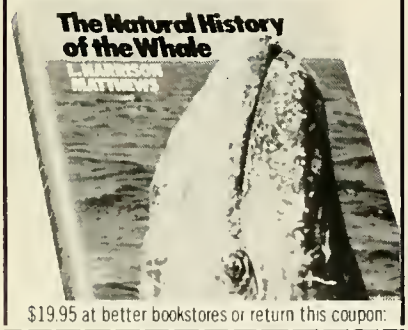
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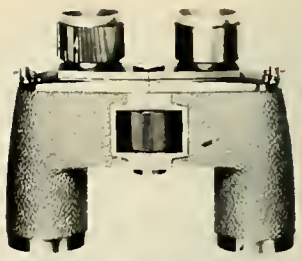
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Eskimo in their homes and communities, the pictures are marvelously evocative. They capture not only landscapes and human appearances (there are some beautiful portraits) but also the range of activities and much of the spirit of interaction between family members and between peers. Looking at them, I felt homesick for Inuit. I particularly liked the sequence shots: a family sitting on the floor, engaged in everyday activities; a man telling a hunting story; and although it is, unfortunately, a bit too dark, a series of a little boy playing with (probably) his mother's face.

The naturalness of facial expressions is, on the whole, impressive; only a few seem self-conscious or unfair to their "owners." And I have never seen a picture that more vividly captures the spirit of Eskimo dancing than one of Alex Harris's. The cultural mix and generational differences are clearly evident, in portraits as well as in photographs of activities (seal hunting from a kayak, caribou hunting from a snowmobile) and of objects (walrus tusks leaning against a washing machine on the tundra). In a few cases, I wished for fuller labeling: What accounts for the unusual grave markers? What are the teen-agers jumping from and to? And why are the caribou head and snowshoes deposited in trees? But these are very minor difficulties in an outstanding series of pictures.

The book ends with a much shorter series of photographs taken by Eskimo themselves from the 1930s to 1970. Most are "formal" photographs. It is interesting to see what situations are defined as calling for a photograph—the killing of a beluga or a walrus, a graduation, the arrival of a plane—and also to see how people pose—men and boys on one side, women and girls on the other. The historical dimension of the pictures might also have been of interest, but we are not given dates or event labels. I found these snapshots a little anticlimactic, perhaps because there are so few of them and because in some cases they are uninterpretable.

Jean L. Briggs is professor of anthropology at Memorial University of Newfoundland and the author of a book on Eskimo, Never in Anger *(Harvard University Press).*



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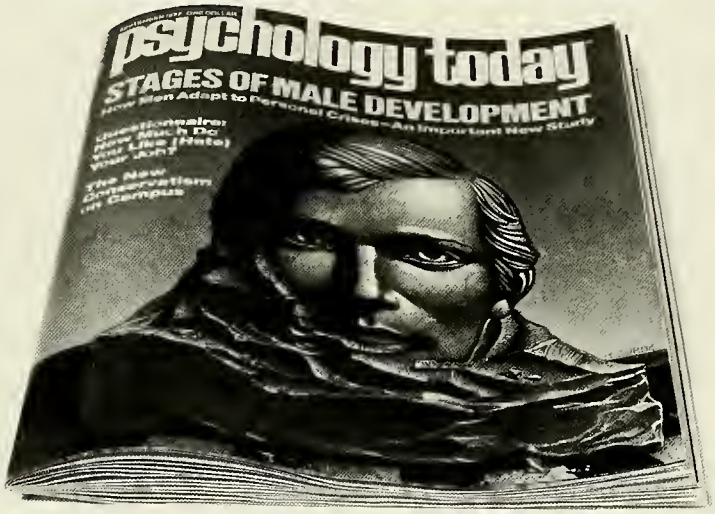
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Celestial Events

by Thomas D. Nicholson

Sun and Moon The sun will be in the far southern sky, in the constellation Ophiuchus, until December 18, and then in Sagittarius until after mid-January. The earliest sunset of the year occurs on December 8; the latest sunrise on about January 5; and the shortest day of the year, when the sun is at the solstice and winter begins, on December 21 or 22, depending on the time zone. The earth reaches perihelion, where it is nearest the sun, on January 4.

We will have an evening moon for the first two weeks of December (and January), and a morning moon for the succeeding two weeks. In December, the moon is at first-quarter on the 6th, full on the 14th, at last-quarter on the 22nd, and new on the 29th. In January, first-quarter is on the 5th, full on the 13th. The moon is nearest the earth (perigee) on December 2 and 30, and farthest (apogee) on the 18th.

Stars and Planets Jupiter shows up on the evening Star Map this month, the first planet we've seen there in some time, even though it is not yet an evening star. We call a planet an "evening star" when it is above the horizon at sunset, and Jupiter doesn't rise until later. But by early evening, it is up in the east, between Gemini and Leo, and remains in the sky past dawn. Saturn is about two hours behind, and from midnight on appears at Jupiter's east (left). When Venus rises, just before dawn, there will be quite a morning sky. During early twilight, Venus is low in the southeast, with Mercury visible below it from the 20th on; Saturn and Jupiter are high in the southwest and west respectively.

December 5: Mercury is at inferior conjunction, between the earth and the sun, and enters the morning sky.

December 12–13: The bright star near the moon is Aldebaran, in Taurus. The moon covers Aldebaran (an occultation) shortly before moonset along the Pacific coast.

December 13–14: The Geminid meteor shower reaches maximum after midnight, providing up to 50 shower meteors per hour, about half as many as in the morning.

December 14: Venus is at greatest brilliancy in the morning sky.

December 15: Mercury ends its retrograde (westerly) movement and begins to move eastward through the stars.

December 17–18: The bright object near the moon is Jupiter.

December 20–21: Saturn is near the moon; Jupiter is the bright object west (right) of them.

December 21–22: Winter commences in the Northern Hemisphere at 21 minutes past midnight, EST, on the 22nd; late on the 21st in time zones to the west.

December 22–23: The Ursid meteor shower can be seen at its best (up to 15 meteors per hour) after midnight.

December 24: Mercury is at its greatest distance from the sun in the morning sky. It may be visible low in the southeast shortly after dawn, below and to the left of Venus, for several mornings before and after this date.

December 26: Venus can be seen at dawn in western North America just under the lower tip of the crescent moon.

December 30: Perigee follows the new moon by one day. The effect of the moon's distance will enhance the normally greater range of spring tides.



★ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:15 P.M. on December 1; 10:20 P.M. on December 15; 9:20 P.M. on December 31; and 8:20 P.M. on January 15; but it can also be used for an hour before and after those times.



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Mission to Venus

Space probes bound for our planetary neighbor should increase our understanding of Earth as well

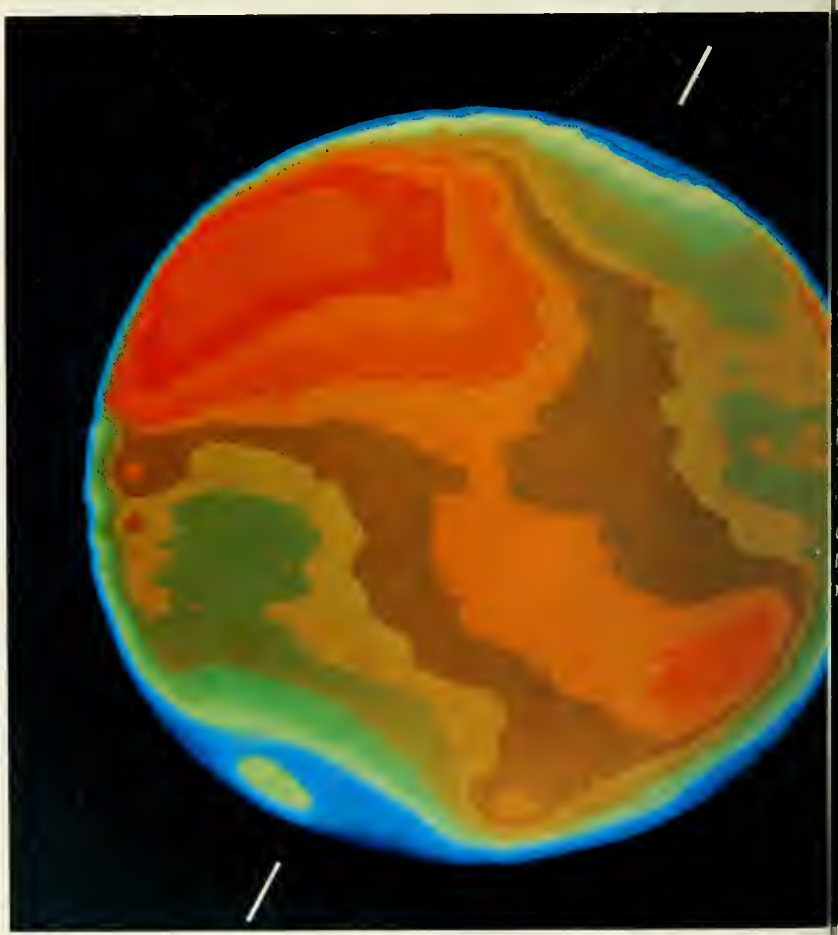
Early in December 1978 two United States spacecraft, called *Pioneers,* will approach Venus. On December 4 (assuming all goes according to plan) one spacecraft, *Pioneer Venus 1,* will go into an elliptical orbit of the planet with a closest approach of 125 miles or less from its surface. On December 9 the second spacecraft, *Pioneer Venus 2,* a multiprobe craft, will release five different instrument packages that will make observations as they descend into the Venusian atmosphere. Four of the probes should reach the planet's surface and may survive there for a short time. Since the temperature of Venus's atmosphere at the surface is about 900°F, hotter than the melting point of lead, it is an engineering feat to reach the planet's surface, let alone to survive there. Long term *in situ* measurements on the surface of Venus are something for the distant future.

Venus is a particularly difficult planet to explore. Its high surface temperature is one problem, but equally important is its ubiquitous, opaque cloud cover, which precludes most of the remote satellite measurements that have been successfully made of Earth and Mars. The United States has already sent three flyby spacecraft to Venus—*Mariner 2, Mariner 5,* and *Mariner 10*—which have given us partial but tantalizingly incomplete information. The Soviet Union has made Venus a prime target for its space program, launching at least ten *Venera* spacecraft, two of which operated on the surface for about sixty minutes and sent back television images of the few yards surrounding the spacecraft.

Approximately ten years ago a small group of U.S. scientists successfully argued that a major effort should be made to advance our knowledge of Venus, our nearest planetary neighbor. The tenor of their argument was that an understanding of the similarities and differences between Earth and Venus would increase our knowledge of both planets, that a few successful measurements could shed much light on questions about Venus, and that those measurements were all within the scope of modern technology. It was further pointed out that experiments on the orbiter and probes could be so designed as to support each other and thereby provide complementary clues to some of the more significant questions about Venus.

The resultant *Pioneer* mission, formulated by 114 investigators of diverse interests from Europe and the United States, is a model of a well-designed scientific investigation. I shall attempt to describe a few of the major questions that concern the researchers, what they expect to learn, and why this knowledge may benefit all of us.

An understanding of the structure and evolution of the interior of the earth is a central problem addressed by geophysicists. They wish to ascertain, for example, how and why our planet has differentiated, that is, why heavier material, principally iron, has gravitated



Jerome Apt

by Richard Goody

to the earth's center; whether the core is molten; how it gives rise to the planetary magnetic field; and how far the earth has progressed along the evolutionary track toward the end when all forms of internal energy will have been dissipated. The clues available on Earth alone are few and unraveling them is a slow and painstaking process. Similarities and differences in closely related planetary bodies such as Venus could open up entirely new ideas.

What do the Venus *Pioneers* have to offer? *Venus 1*, the orbiter, can map the Venusian gravitational field and, equipped with a radio altimeter, provide elevation maps

is color-enhanced temperature p refers to Venus's cloud tops, ut forty miles above the face. Red is hot, blue is d. Maximum temperature ferences are approximately F. White marks indicate planet's axis of rotation. image was made with the y-inch telescope at unt Hopkins, Arizona.



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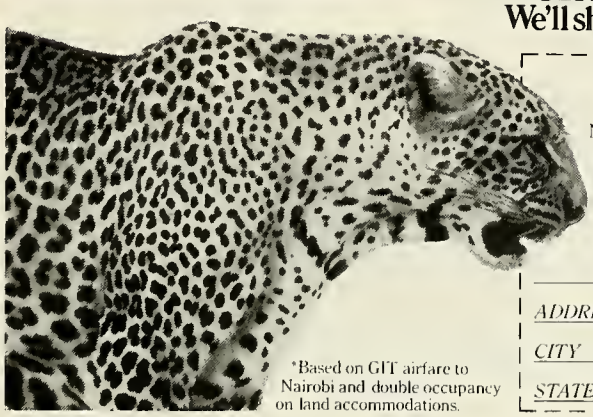
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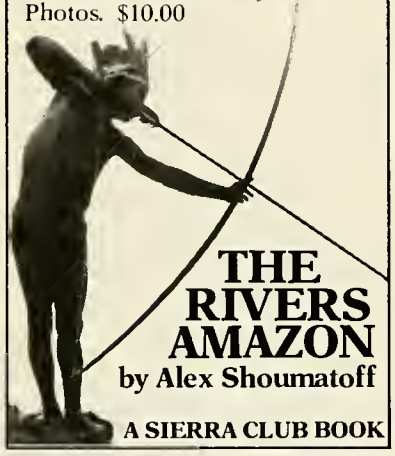
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of the surface. We know from ground-based studies made by radar, which can penetrate clouds, that large local and continental-sized height contrasts exist. This leads us to conclusions about the strength of the interior rocks. We can also calculate internal mass distributions and hence decide whether the observed rotation of Venus can be accounted for in terms of gravitational interactions between Venus and Earth.

This last question is sufficiently interesting for a brief digression. Earth-based radar studies have established that Venus rotates unexpectedly slowly—once in about 243 days—and in a retrograde sense, that is, in a direction opposite to almost all other solar system bodies and orbits. The slow rate of rotation may have a curious consequence, namely, that whenever Earth and Venus are closest (in conjunction, in astronomical language) the same feature on the Venus surface appears to face the earth directly. It is not difficult to see that periodic gravitational impulses, such as might result from a large, raised continent placed at this point on Venus, could tend to lock the orbits together in the manner observed. To establish this mechanism in detail requires knowledge of the physical properties and mass distribution in the interior of Venus, and if our models can be shown to be consistent with the planet's anomalous rotation, our confidence in them is increased.

The orbiter can also measure the Venusian magnetic field. We know from the USSR *Venera* measurements that the magnetic field is small—approximately one thousand times smaller than the earth's. Does this imply that Venus does not have a molten metallic core? Or is some other feature of the planetary dynamo missing or weak? A careful survey of the magnetic field may clarify these issues.

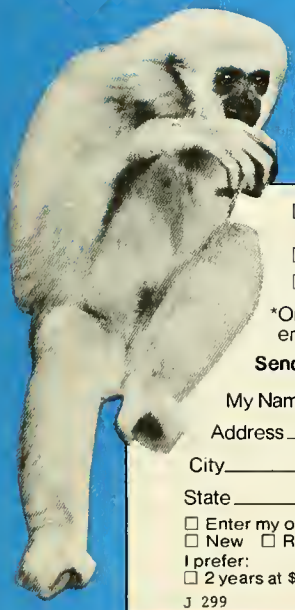
If the planet has a metallic core, it is, of course, differentiated, for if we understand anything at all about the formation of the planets in our solar system, Venus could not have started off that way. Another approach to the interior structure of Venus is to examine the planet's surface to see whether its physical state or chemical composition implies interior processes. For example, basaltic flows, which are common on the earth, moon, and Mars, imply volcanism, which, in turn, implies massive reorganization of the object's interior. The presence of igneous rocks, such as granites, has a similar implication. *Venera* spacecraft have turned up both kinds of evidence. Radio-chemical analysis of the surface has indicated igneous, possibly granitic, rocks at one location. Television pictures of the surface have suggested debris of a basaltic origin at another.

Pioneer Venus 2 is equipped with an elaborate chemical laboratory that will be carried to the surface in the largest of the multiprobes. Samples of the atmosphere rather than the surface itself will be analyzed, but that is not an important distinction because the high surface temperature and surface pressure (approximately ninety times that of the earth) insure an intimate chemical relationship between surface and atmosphere. We may therefore regard the atmosphere as an accessible extension of the surface.

These carefully designed chemical experiments are central to the Venus mission. They will not only tell us a great deal about the surface but they are also important to our understanding of atmospheric processes, particularly the layer or layers of cloud that shroud the planet. Such chemical data are also essential for constructing the past history of the Venusian atmosphere, and this could help us understand the past history of the earth's atmosphere, which connects with ideas about future terrestrial evolution and change.

The radio altimeter, already referred to, will supply surface maps of the planet that may carry significant information about the crust and interior. Radio waves can penetrate the cloud cover and delineate the surface in a way that is impossible for the eye or a television camera. Interestingly, the maps obtained will not provide more detail than that available from ground-based radiotelescopes. The large antennas that now exist, especially if used in combination with each other, have already given us partial maps showing mountains, craters, and other features. The earth-based observations cover only a small fraction of Venus's surface, however, and the orbiter will greatly extend this coverage.

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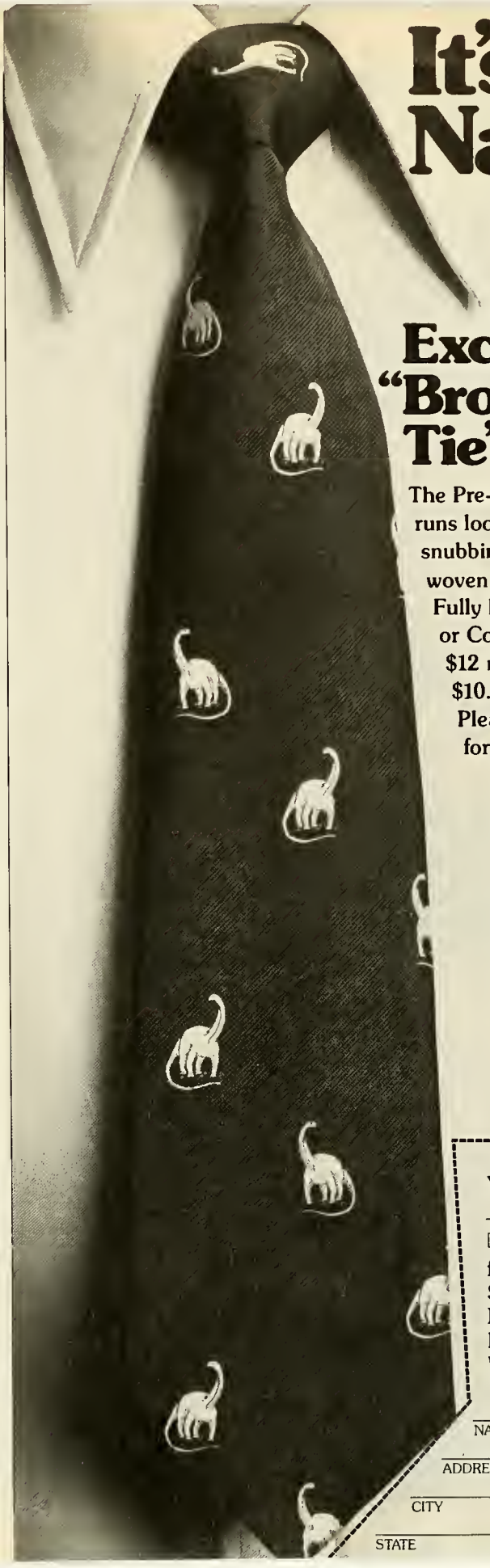
The maps obtained will be studied for information on dynamical processes in the crust. Are huge plates constantly being created and destroyed, as on the earth, or is the crust thick and unbroken, as on the moon and Mars? Can we detect relatively young volcanoes and do basaltic flows exist, indicating the possibility of earlier volcanism?

Turning to the atmosphere, the situation on Venus is quite different from that on Earth, yet we believe that the evolution of the present Venusian atmosphere and the physical processes that govern its behavior are related to similar processes on the earth.

The cloud cover on Venus is one of the prime targets for investigation. We not only have to confirm our theories about its composition and find out why, unlike that of the earth, it is horizontally complete and unbroken, although vertically layered, but we must also learn how it influences other phenomena such as surface temperature and global wind systems.

Our present state of knowledge about Venus's clouds is as follows. Between forty-five and fifty-five miles above the planet's surface there are some thin and relatively unimportant cloud layers. The bulk of the cloud lies twenty to forty miles above the surface and consists, we believe, principally of small drops of sulfuric acid. Below that there may be a relatively cloudless layer. The cloud is formed not by the familiar condensation process responsible for most terrestrial clouds but rather by a series of chemical reactions more similar to those in an urban smog.

The four *Pioneer Venus 2* probes (one large and three small) designed to reach the surface can make a variety of measurements, all related to the cloud layer. A small cloud detector will indicate the presence of cloud and measure its opacity. On the large probe an instrument will measure the concentration and size of cloud particles, essential parameters for understanding the processes destroying the cloud. (The atmosphere is dynamical, not static. And because nature must preserve a balance, clouds are formed and destroyed at the same rate. Cloud formation must therefore be accompanied either by dissipation by chemical processes or by precipita-



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tion to the hot lower atmosphere.) The chemical measurements, already mentioned, are designed to determine conclusively the chemical composition of any observed cloud layer.

Finally, two sets of instruments will not only provide data on the cloud but also measure the cloud's influence on incoming solar radiation and the outgoing long-wave heat radiation that cools the planet and maintains it in a balanced state. Both radiation streams will be measured independently or in combination on all four of the deep atmospheric probes.

One of the most important features of these radiation experiments is the possibility they offer of insight into why the surface temperature is so high. An elementary calculation suggests that Venus's clouds reflect so much sunlight that the surface should be, on the average, well below the freezing point of water. Apparently the cloud has a more complex function. It permits a few percent of the incident sunlight to reach the surface while at the same time it is extremely opaque to penetration by long-wave radiation. Heat is thereby trapped near the surface and the temperature rises to unexpected values.

We may understand this problem in its general outline but that is not sufficient, for if Venus can behave in this way, so might the earth. We must be very clear about those factors that have led the two planets into such dramatically different states.

The second central problem concerning the lower atmosphere is that of the global wind system. The physical laws of motion challenge our general state of knowledge as to how atmospheres function, and the slow rotation of Venus should give rise to motions with some similarity to those occurring in the tropical regions of the earth. Modern meteorology places increasing importance upon these tropical flows and their influence on the entire planet.

The predominant flow of the lower atmosphere on Venus probably carries heat directly from the tropics to the poles by means of two huge cells that rise in low latitudes and sink in high latitudes. The driving force for this circulation is the difference in heating and

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cooling caused by absorbed solar radiation and radiation emitted by the planet over distances of global dimensions. To understand the circulation we have to measure the difference, which was one of the primary motivations for the multiple-probe concept. Four probes will measure the temperature, pressure, and heat balance of the atmosphere, in addition to the presence of cloud at four points as widely spaced as the mechanics of the mission permit. One possible configuration places two probes at 30°S, one at the equator, and one at 56°N, with a maximum longitudinal spread of 100°.

At each of these four locations we expect to measure the winds with an accuracy of about one mile per hour at twenty to thirty different heights in the atmosphere. This will be done by an ingenious system in which radiotelescopes on the earth will track the probes. The idea may be difficult to grasp, but the probes at Venus—some 33 million miles away—will be located, relative to each other, from Earth to a precision of a yard or two.

That the atmospheric motions of Venus are not simple is already known. The picture we have developed for the lower atmosphere does not pertain to the cloud tops. There a strong wind blows in a predominantly east–west direction at speeds up to 250 mph. These winds can be seen in pictures whose resolution is great enough to detect small moving clouds, and measurements of this type will be made from the orbiter. Why one wind regime gives way to another so different is a puzzle that remains to be explained.

To conclude, let us follow the sequence of events expected to occur early in December. The orbiter, which will arrive first, embodies a relatively familiar concept—we have put many similar spacecraft into orbit around the moon, the earth, and Mars. This one will transmit data to the earth for at least eight months. The multiprobe is more unusual.

The four probes designed to reach the surface of Venus, together with their heat shields, are attached to one side of a carrier spacecraft. Twenty-four days before entry into the Venusian atmosphere, the single large probe will be released and will follow a ballis-

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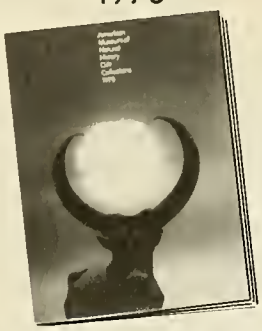
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tic trajectory into the atmosphere. The spacecraft will then be spun slowly on its axis so that when the small probes are released, four days later, centrifugal force will carry them on slightly different trajectories from each other and from the large probe.

This leaves the carrier, to which the probes were attached. It also is instrumented but has no heat shield. After the small probes have been released, the carrier will be retargeted and will burn up like a meteor in the upper Venusian atmosphere but not before it has made important measurements in that region.

The probes with heat shields will continue their journey. At sixty miles above the surface the decelerating effect of the atmosphere will be felt, and at fifty miles the maximum deceleration will take place.

Inside the probes, sealed pressure vessels made of titanium with some insulation will protect the instruments from the heat of the lower atmosphere. One of the most challenging engineering tasks of the mission was to construct these vessels from a difficult-to-handle material, make them pressure tight and thermally insulated, and yet to provide windows and access ports for the instruments to sample the exterior atmosphere.

The probes will take almost sixty minutes to fall from about forty-two miles, where measurements begin, to the ground. If that sounds slow, the reader should realize that the dense lower atmosphere of Venus is more akin in some ways to the earth's oceans than to its atmosphere. The large probe will fall somewhat faster than the small probes and, to compensate, will carry a parachute to be used during the first seventeen minutes of descent.

The multiprobe mission, after ten years of preparation, will last only sixty minutes, plus the very short time that the probes can be expected to survive on the surface of Venus. That single hour, however, should revolutionize our views of the surface and lower atmosphere of the planet most similar to our own.

Richard Goody is Mallinckrodt Professor of planetary physics at Harvard University.

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Additional Reading

Atlantic Salmon (p. 38)

A complete bibliography on the Atlantic salmon was published in 1962 by the Department of Game and Fisheries, Province of Quebec, Quebec, Canada: *Bibliographie du saumon de l'Atlantique,* by Julien Bergeron. Two more up-to-date books on the subject are by Anthony Netboy. The first is *The Atlantic Salmon: A Vanishing Species?* (Boston: Houghton Mifflin Co., 1968). This study of the history of Atlantic Salmon, with seventeen pages of references, is the result of extensive field and library research in Europe and the United States. The second, *The Salmon: Their Fight for Survival* (Boston: Houghton Mifflin Co., 1974), has an interesting discussion on primitive man and the Atlantic salmon.

Hawaiian Tree Snails (p. 46)

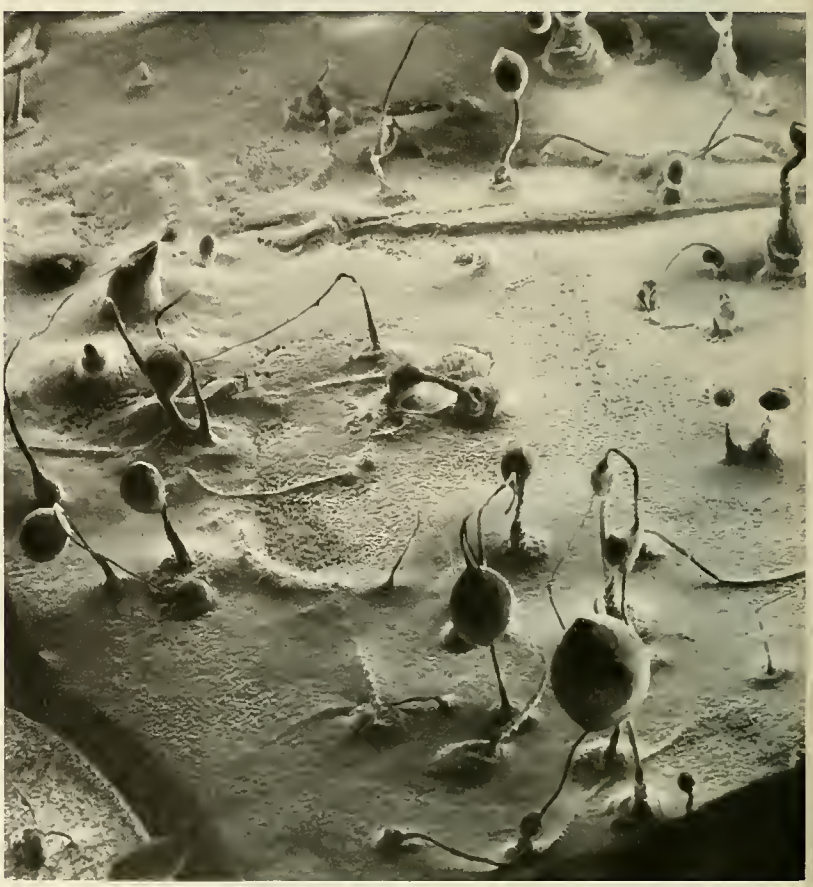
Most publications about Hawaiian tree snails are highly technical, outdated, or out of print. A general introduction to the snails' environment is *Hawaii: A Natural History*, by Sherwin Carlquist (Garden City: Doubleday/Natural History Press, 1970). *Mollusks,* by Paul Bartsch (New York: Dover Publications, 1968), includes pictures of Hawaiian tree snails and mentions them briefly in the text. *The Shell Makers: Introducing Mollusks,* by Alan Solem (New York: John Wiley and Sons, 1974), deals with marine and land mollusks.

Neanderthals (p. 58)

Two paperback introductions to the subject are *Evolution of the Genus Homo,* by W. W. Howells (Reading: Addison-Wesley Publishing Co., 1973), and *Neanderthal Man*, by Kenneth A. R. Kennedy (Minneapolis: Burgess Publishing Co., 1975). *Shanidar: The First Flower People*, by R. S. Solecki (New York: Alfred A. Knopf, 1971), is an illustrated, personal account of the excavations at Shanidar Cave. Although out of print, it can be found in some libraries. A well-known, excellent introduction is John Pfeiffer's *Emergence of Man*, now in second edition (New York: Harper and Row, Publishers, 1972). The author has also written *The Search for Early Man* (New York: American Heritage Publishing Co., 1963) for young adults. It is illustrated with paintings and pictures of prehistoric engravings and sculptures from the Lascaux caves. Two books published by Time-Life Books, New York, are *Early Man,* by F. Clark Howell, rev. ed. (Life Nature Library Series, 1973), for grades 5 and up, and *The Neanderthals,* by George Constable (Emergence of Man Series, 1973).

Monthly Rhythms (p. 64)

Information on several international conferences on biological timing, held from 1960 to 1973, can be found in the preface of *Living Clocks in the Animal World,* by Miriam F. Bennett (Springfield: Charles C. Thomas Publisher, 1974). The book discusses biological clocks of fiddler and other crabs, honeybees, earthworms, and certain mollusks and amphibians. For readers who have no special background in science, there is the illustrated *Rhythm Phenomena in Plants,* by B. M. Sweeney (New York: Aca-



Cellular Slime Mold Spore Towers (27X) David Scharf

demic Press, 1969), which also draws on animal studies. The yearly emergence of the palolo worm in Samoa is discussed in "Night of the Palolo," by Barbara Smetzer (*Natural History*, November 1969). *The Physiological Clock*, by Erwin Bunning, 3rd ed. (New York: Springer-Verlag New York), is a heavily illustrated, technical book. In addition to his articles in *Natural History* (see "Authors," page 4), John D. Palmer has written a number of books, including *An Introduction to Biological Rhythms* (New York: Academic Press, 1976) and *Biological Clocks in Marine Organisms* (New York: John Wiley and Sons, 1974.) His article on "Biological Clocks of the Tidal Zone," appeared in the February 1975 issue of *Scientific American*.

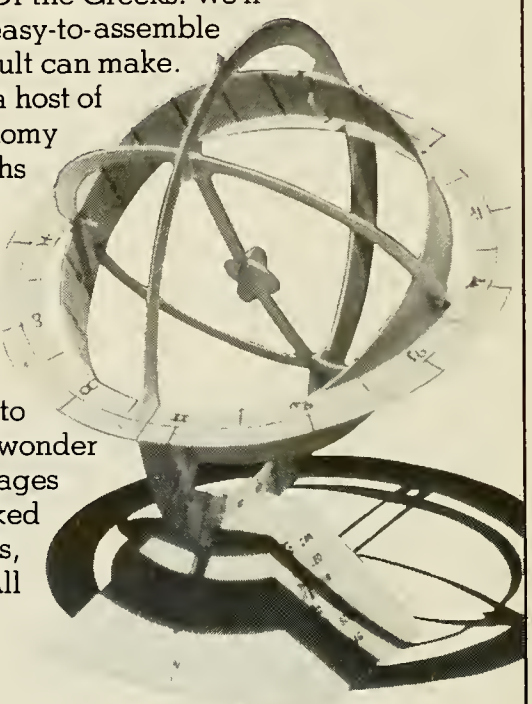
Slime Molds (p. 70)

Chapter 7 of *Eloquent Animals: A Study in Animal Communication*, by Flora Davis (New York: Coward, McCann and Geoghegan, 1978), discusses slime molds and John T. Bonner's work at Princeton. Bonner's classic monograph is *The Cellular Slime Moulds*, 2nd ed. (Princeton: Princeton University Press, 1969). More up to date is *Dictyostelium discoideum: A Developmental System*, by William F. Loomis (New York: Academic Press, 1975), with photographs of slime molds in various stages. *Development and Differentiation in the Cellular Slime Moulds*, edited by P. Cappuccinelli and J. M. Ashworth (New York: Elsevier/North Holland Biomedical Press, 1977), is the proceedings of the 1977 international conference on cellular slime molds. The work is illustrated with graphs and photographs. Chapter 3 of *The Mycetozoans*, by Lindsay S. Olive (New York: Academic Press, 1975), treats the subject of slime molds.

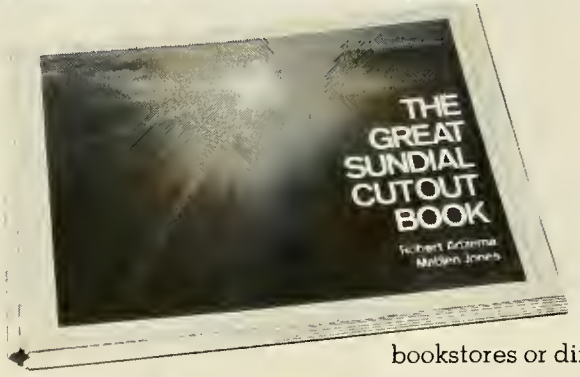
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At the Museum

Two signs, classic as Advent calendars, herald the approach of Christmas for Museum visitors. One is the **Star of Wonder** show at the Hayden Planetarium, which begins on November 22. As essential a part of a New York schoolchild's holiday as *The Nutcracker Suite*, the Planetarium show re-creates the sky over Bethlehem at the time of Christ's birth and summarizes theories of the star's origin, for which science now offers as many hypotheses as science fiction does.

The year 1978 will be the sixth year of the Museum's other Christmas classic, the **Rotunda Origami Tree.** This year's tree, wider than before, will boast a larger star mobile and a veritable Noah's ark of more than 1,500 glistening foil birds and other animals, plants, crystals, and stars, as well as angels and crèche figures under the lowest branches. The tree's impresario is Alice Gray, scientific assistant in the Museum's Department of Entomology, who first picked up an origami book fifteen years ago because it pictured an insect on the cover. Starting in September, with help from the New York Origami Society, Gray teaches Museum volunteers, and employees on their lunch hour, to make dinosaurs, whales, skunks, tigers, flying geese, vultures, and even pelicans from gift wrap. "The pelican is complicated; he's an advanced lesson," explained Gray, reciting, "A wonderful bird is the pelican/His bill will hold more than his belican."

During December, Museum volunteers will demonstrate origami techniques around the tree on an ad hoc schedule. The 150 different designs on the tree come from America, Japan, and England. Although no one knows exactly where origami began, Gray speculates that this "fugitive craft" traveled, along with the paper, from China to Japan in the eleventh century. Indeed, Japan Airlines has asked the Origami Center of America, of which Miss Gray is an Associate, to decorate a tree for their window at Fifth Avenue and 53rd Street.

One passer-by who won't be attracted by a tree decorated with man-made objects is paleontologist Sidney Horenstein of the Museum's Department of Invertebrates. Shortly before Christmas, Horenstein will lead one of his **Urban Fossil Hunts** down Fifth Avenue, looking for fossils in building stones.

Horenstein, whose three great loves are "maps, fossils, and New York City," combines them regularly by leading fossil hunts through such unexplored frontiers as the canyons of lower Manhattan's financial district, the boathouse in Central Park, and the tombstones and mausoleums of Woodlawn Cemetery in the Bronx. (For schedules, write to him care of the American Museum of Natural History.) These unusual field trips grew out of his conviction that since man is natural, the city is simply another aspect of natural history. Horenstein's studies of urban geology and paleontology include compiling a catalog of the Museum's building stones: the materials used; where the stones and the fossils they contain came from; how they arrived at the building site; how they have changed since construction. Recently, we followed Horenstein around the Museum to hear some of its stones' stories.

In order to interpret building stones and date their fossils, Horenstein has learned to climb around quarries, read architectural plans and specifications, and translate construction-trade jargon. He has consulted the Museum's original plans but finds they are frequently misleading: "For all sorts of reasons, the stones were often changed at the last minute." Nevertheless, many parts of the Museum could not be replaced today. For example, the beautiful Verd Antique marble from Vermont, lavished as veneer on the Hall of African Mammals, now costs $32 per square foot.

As we began our tour at the 77th Street entrance, near the oldest section of the Museum, Horenstein told us that the building's most ancient stone, a granite from Minnesota in the Auditorium's outer wall, is more than a staggering two billion years old.

Inside, in the Hall of Northwest Coast Indians on the first floor, Horenstein pointed out some wiggly lines in the Tennessee marble at the base of a headdress case on the right: "These are fragments of fossils that altered as the rock recrystallized."

Passing out of the second floor's Hall of African Mammals into the corridor to the Rotunda, Horenstein found fossil sponges in the Rouge Fleuri marble from Knoxville, Tennessee, on the right-hand wall. The stairs from this corridor to the third floor are made of Italian travertine, probably cut from the same quarry as the blocks used in Rome's Coliseum. Low, plantlike growths on the stone once filled the shallow, irregular holes in the steps.

As we rounded the corner and entered the Rotunda, Horenstein pointed out the right-hand wall of "Renfrew marble, actually a limestone from Ashburton, England." This wall is covered with gray splotches that are brachiopods and fossil sponges—"not a coral reef, but a sponge reef." On the left, toward the Hall of Oceanic Birds, the Saint Florient Cream marble wall dates from the Cretaceous and contains "very unusual fossils. This wall is part of a rudistan reef, a reef of clams that died with the dinosaurs." At the north end of the Rotunda, the Sainte Genevieve Golden Vein marble at the entrance to the Hall of Oceanic Birds is actually limestone from Missouri, 350 million years old, made up of solid fossil coral, whose circular shapes and radial spokes are plainly visible. Concluding his tour, Horenstein reminded us that many of the trees around the Museum are gingkoes, living fossils that have survived without evolving.

A good Sunday to look for the Museum's living and petrified fossils would be March 18, when the New York Paleontological Society, which Horenstein founded, will hold a special program, "Fossils for Kids," at 2:00 P.M. in Education Hall. Children can scrutinize the Museum's building stones, see a slide show on how fossils form, and play "Dinosaur Bingo."

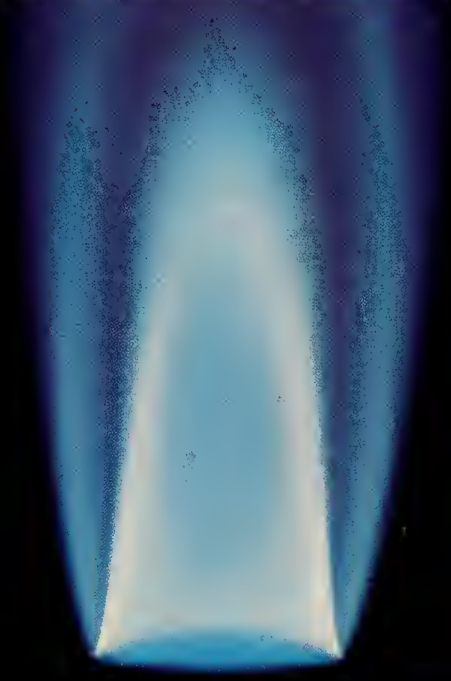
Ann Marie Cunningham



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